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(54) EXPANDABLE SPINAL FUSION IMPLANTS AND RELATED INSTRUMENTS AND METHODS

(71) Applicant: **NuVasive, Inc.**, San Diego, CA (US)

(72) Inventors: **Erika Lin**, San Diego, CA (US); **Jeremy Malik**, San Diego, CA (US); **Ryan Donahoe**, San Diego, CA (US); **Christopher Stein**, San Diego, CA (US); **David Hannah**, San Diego, CA (US)

(73) Assignee: **NuVasive, Inc.**, San Diego, CA (US)

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(22) Filed: **Oct. 22, 2013**

Related U.S. Application Data

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(51) **Int. Cl.**
A61F 2/44 (2006.01)

(52) **U.S. Cl.**
CPC ***A61F 2/4455*** (2013.01)

(58) **Field of Classification Search**
CPC A61F 2/4611; A61F 2/446; A61F 2/447; A61F 2/44; A61F 2/442; A61F 2/4455; A61F 2/4465
USPC 623/17.11, 17.16
See application file for complete search history.

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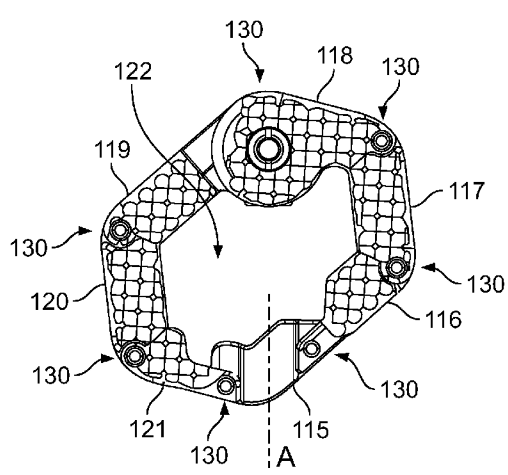
Primary Examiner — Kevin T Truong
Assistant Examiner — Si Ming Ku
(74) *Attorney, Agent, or Firm* — Jeremy A. Smith; Bradley Arant Boult Cummings LLP

(57) **ABSTRACT**

A system for performing interbody fusion surgery including an expandable intervertebral spacer and specialized instruments for choosing the correct size of implant, implanting the device within the intervertebral space, and for delivery of bone graft or bone substitute to the interior of the implant.

7 Claims, 34 Drawing Sheets



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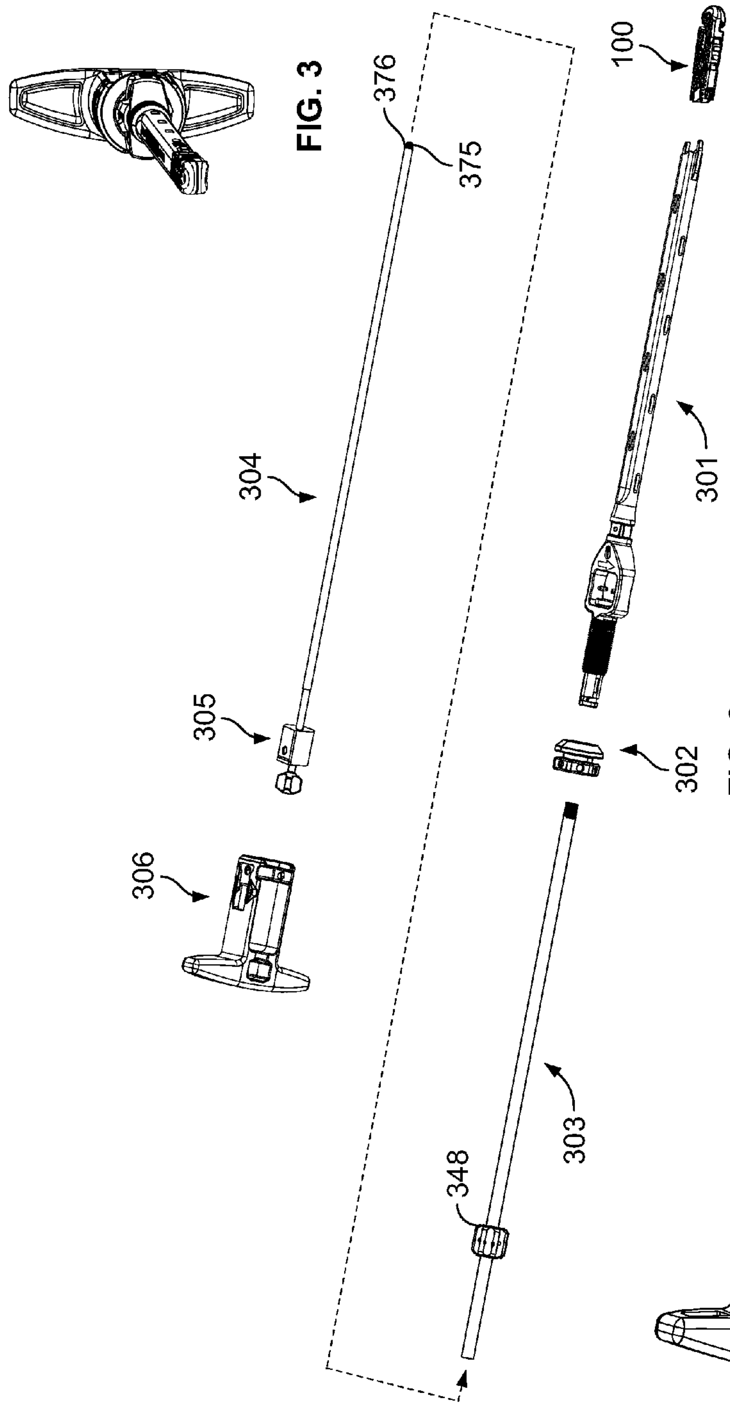

FIG. 3

FIG. 2

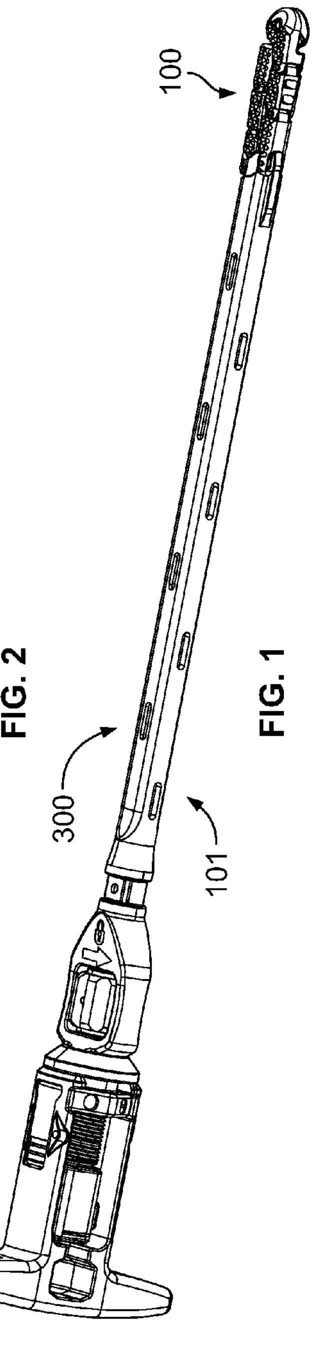

FIG. 1

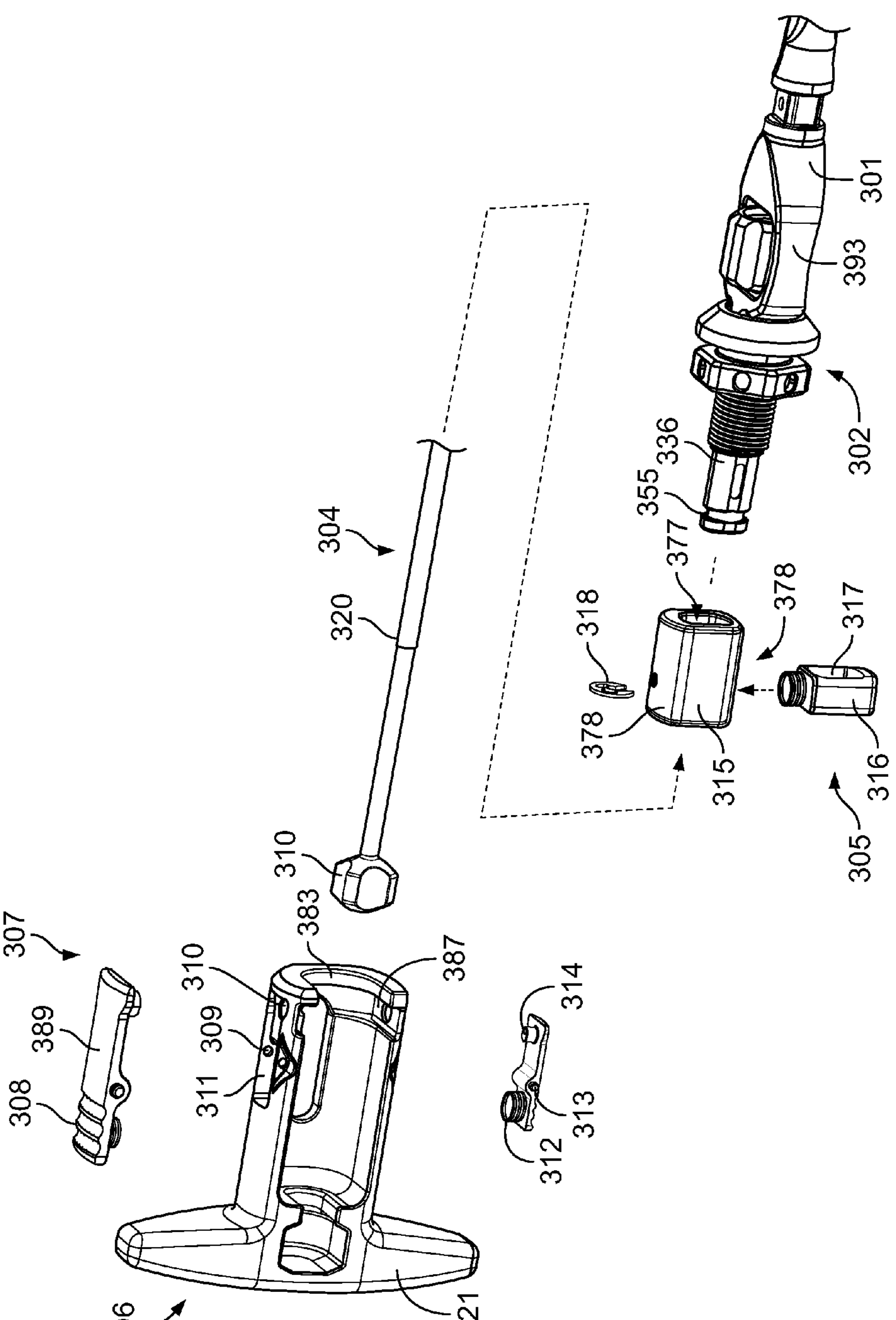
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FIG. 4

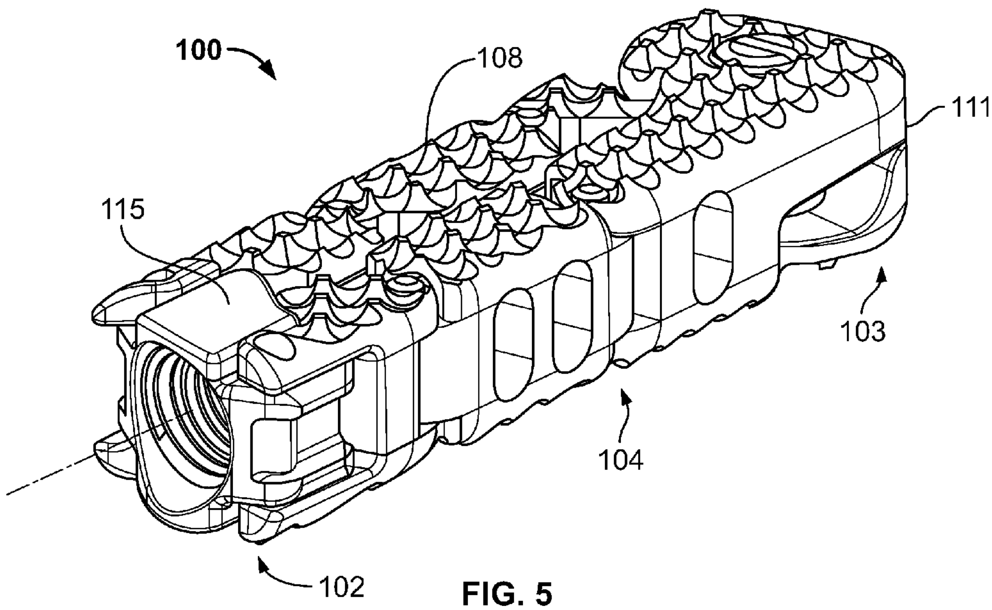

FIG. 5

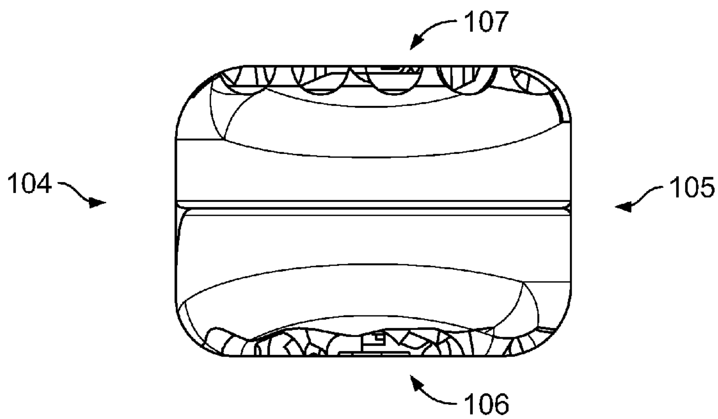

FIG. 6

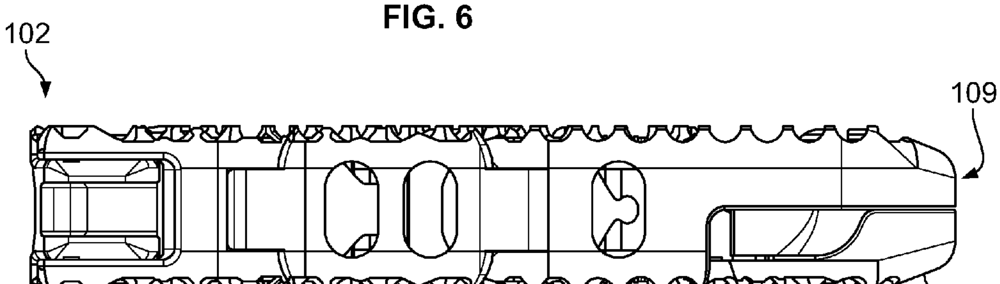

FIG. 7

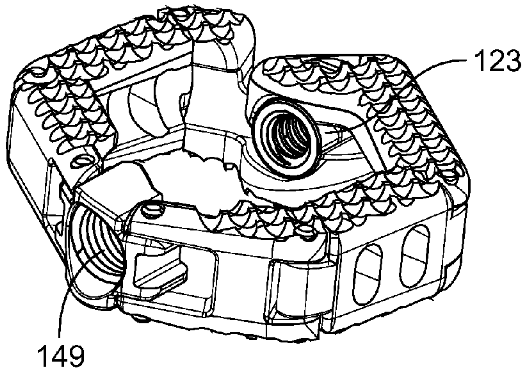

FIG. 8A

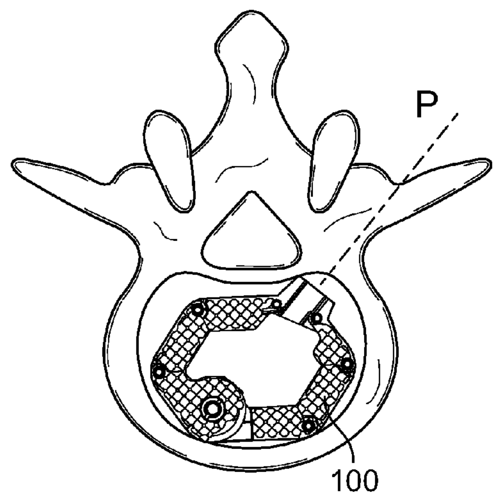

FIG. 8B

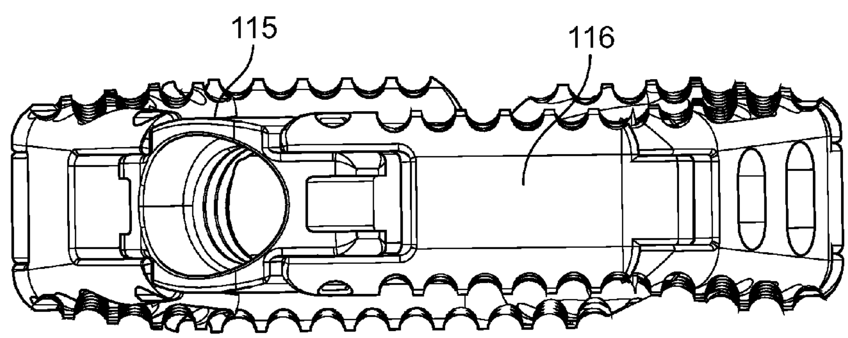

FIG. 9

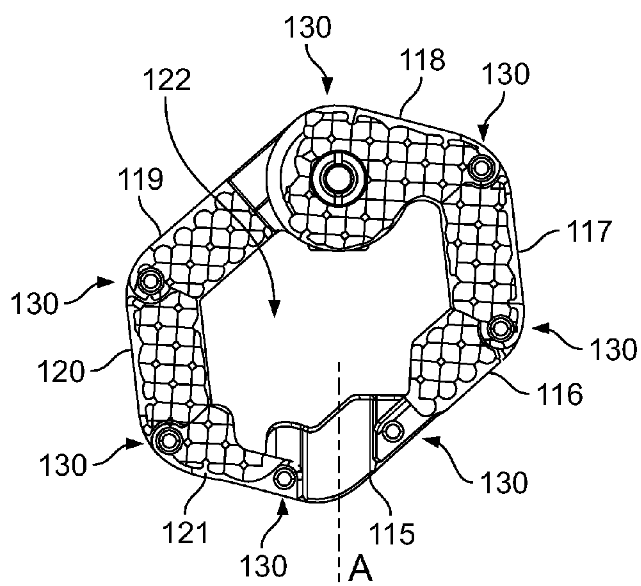

FIG. 10

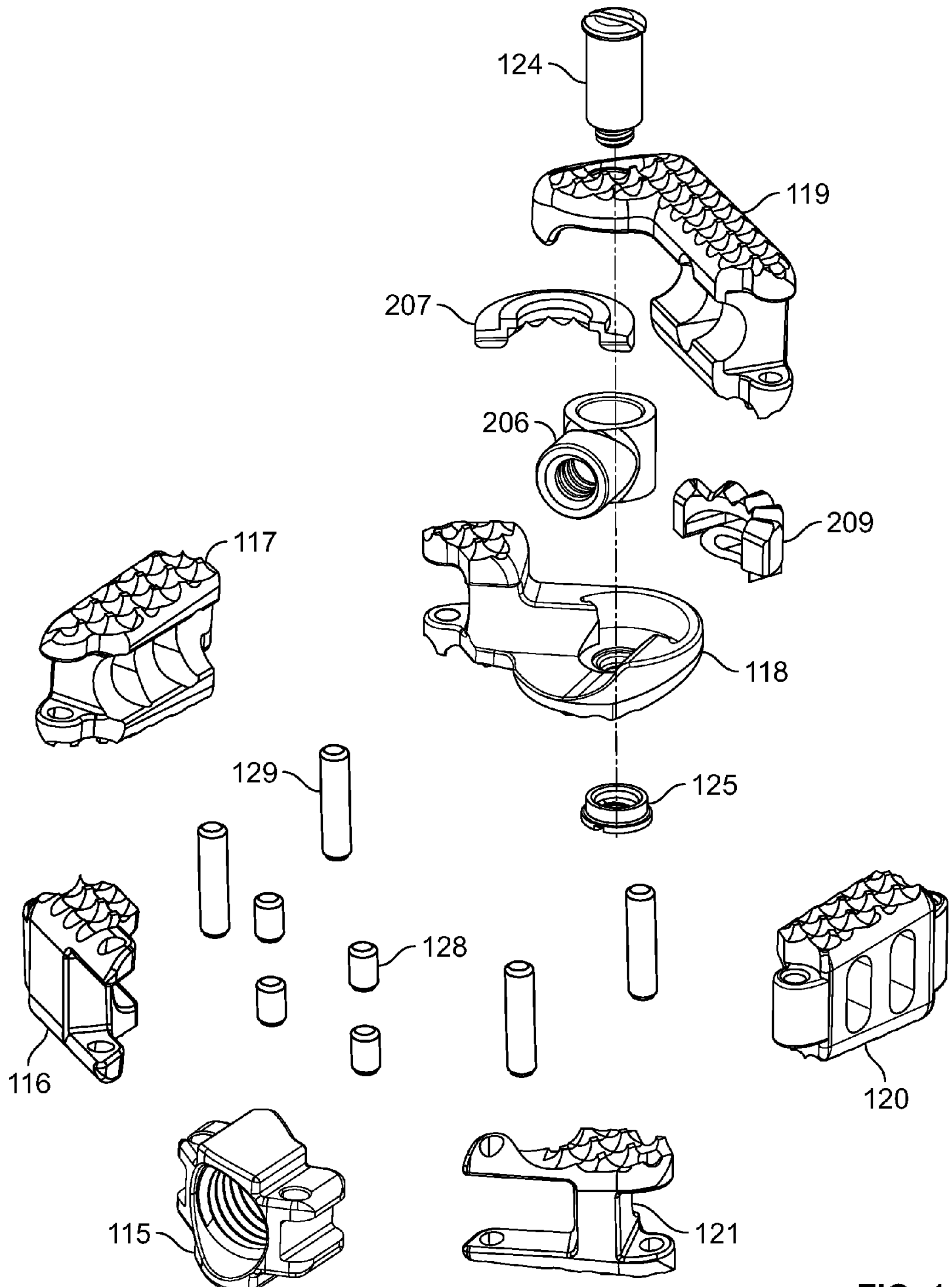

FIG. 11

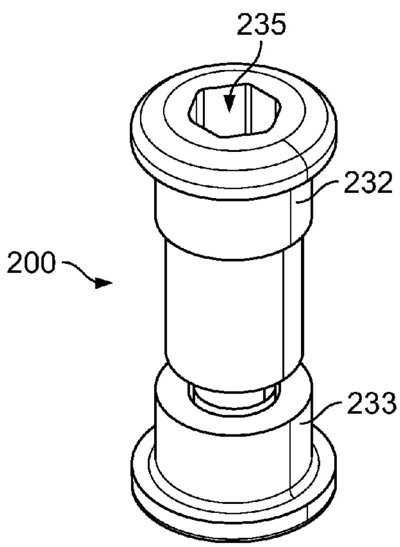

FIG. 12

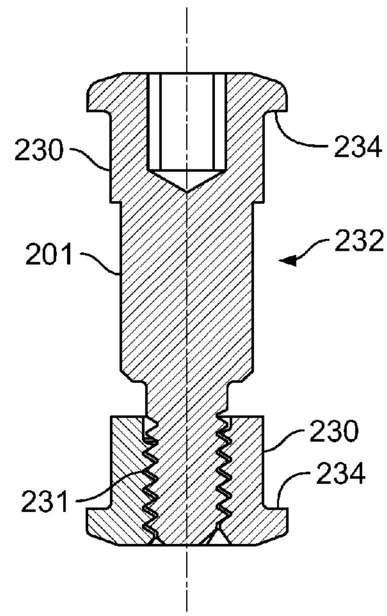

FIG. 13

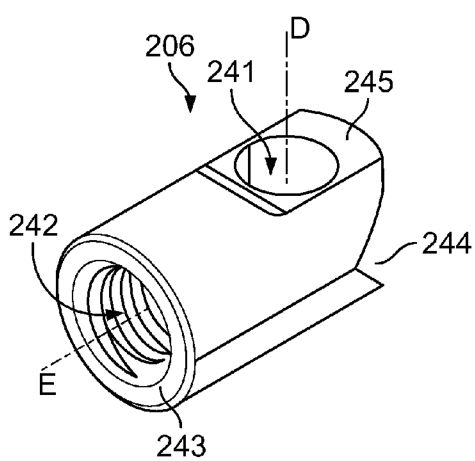

FIG. 14

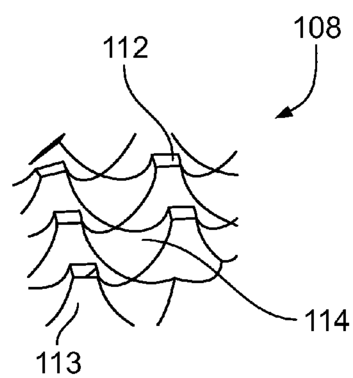

FIG. 15

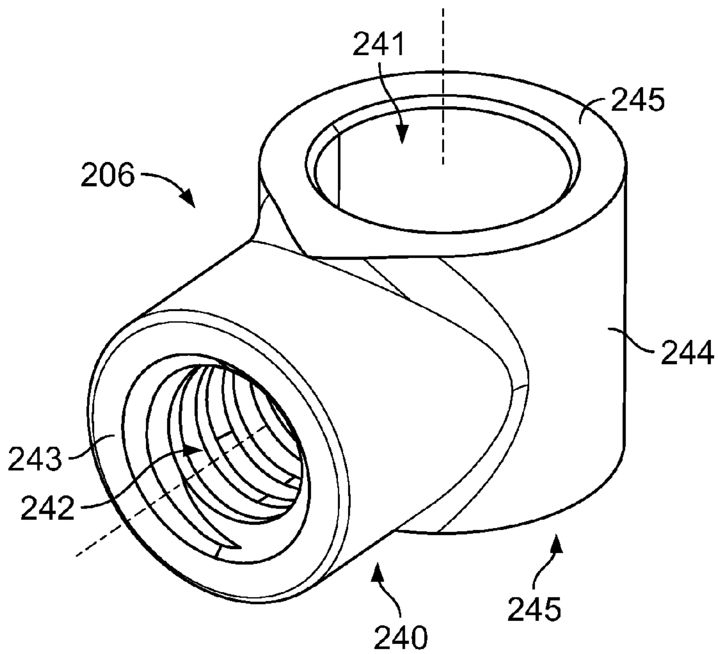

FIG. 16

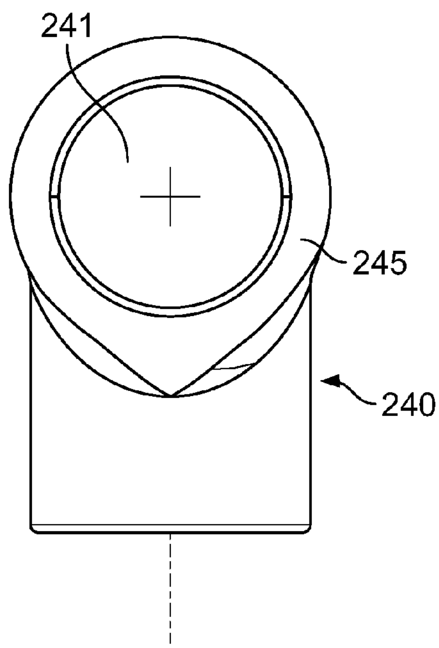

FIG. 17

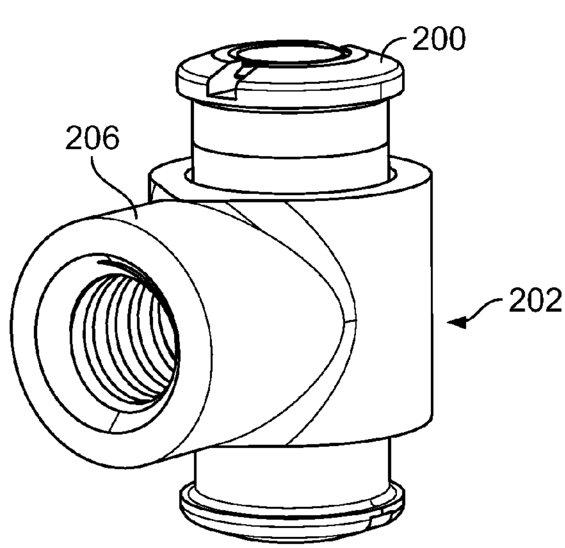

FIG. 18

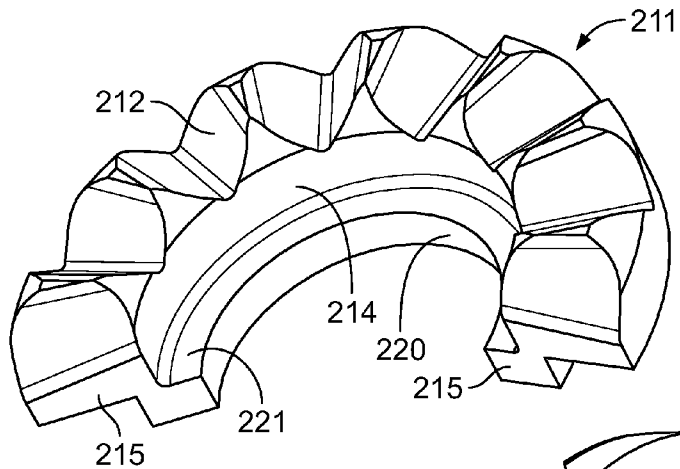

FIG. 19

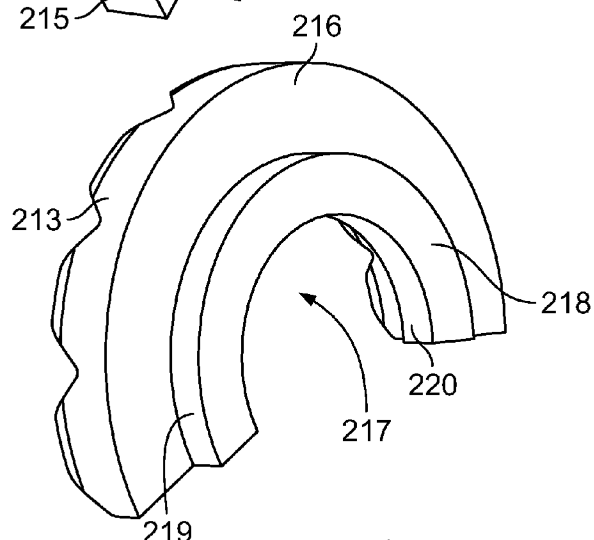

FIG. 20

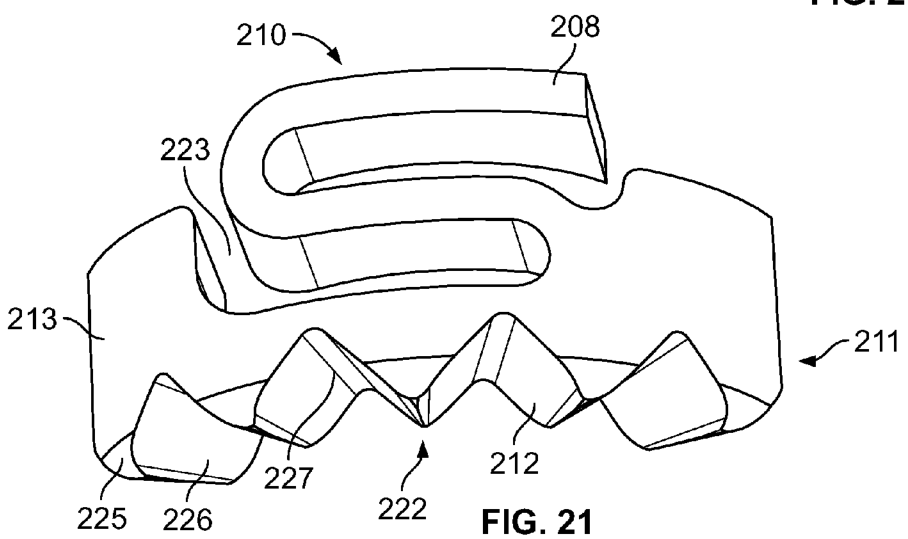

FIG. 21

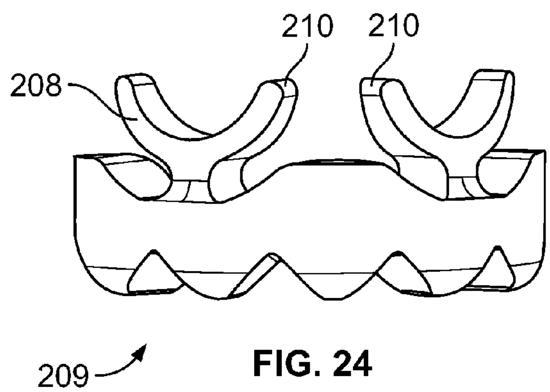

FIG. 24

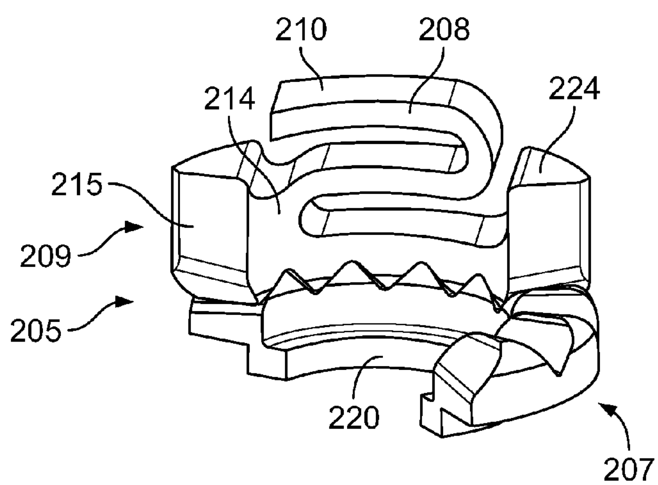

FIG. 22

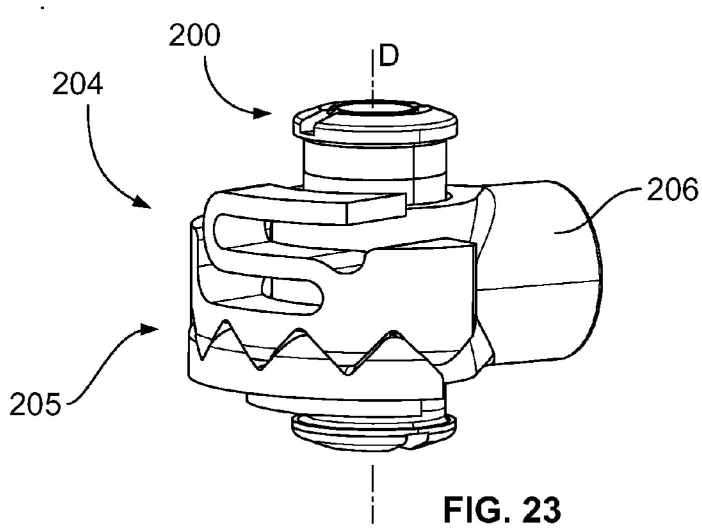

FIG. 23

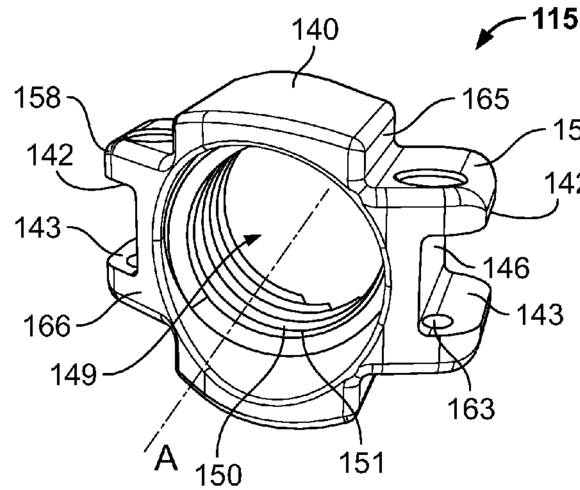

FIG. 25

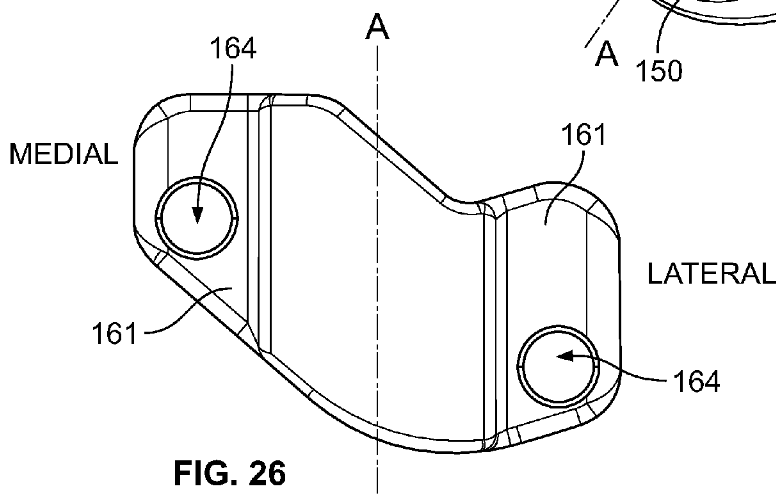

FIG. 26

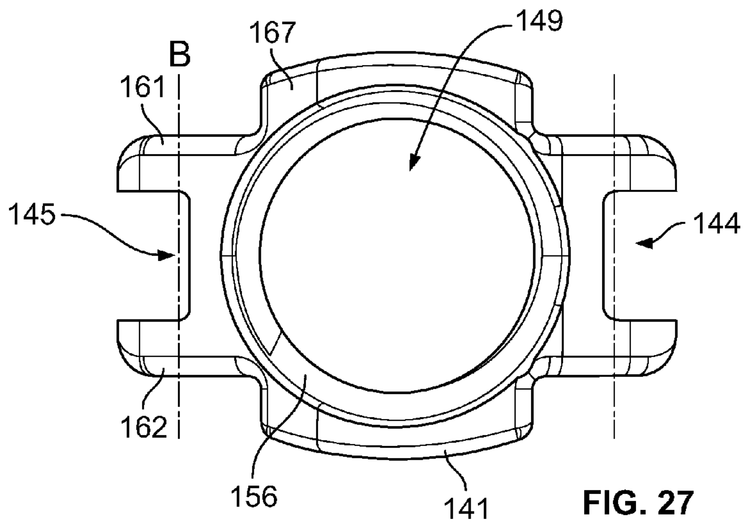

FIG. 27

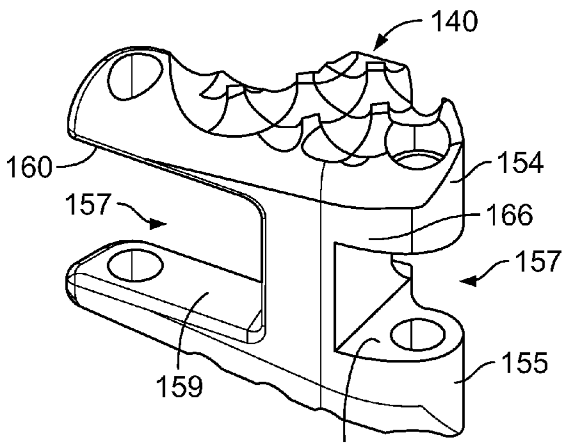

FIG. 28

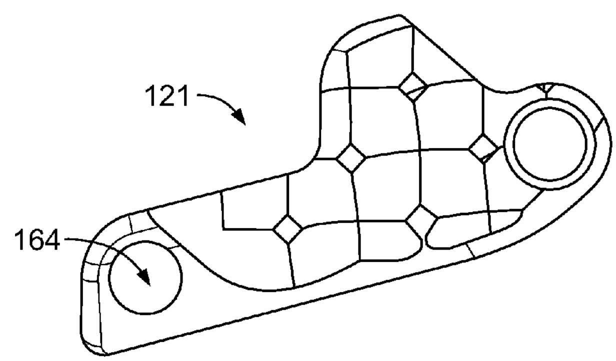

FIG. 29

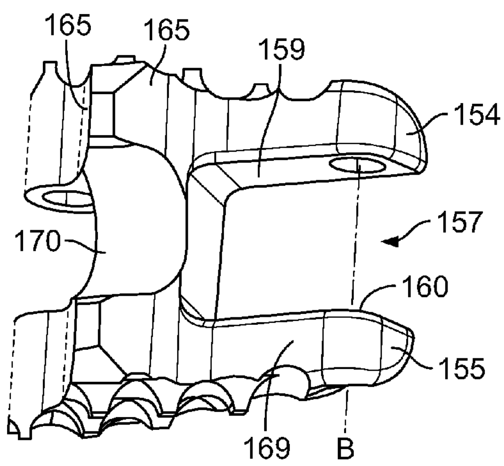

FIG. 30

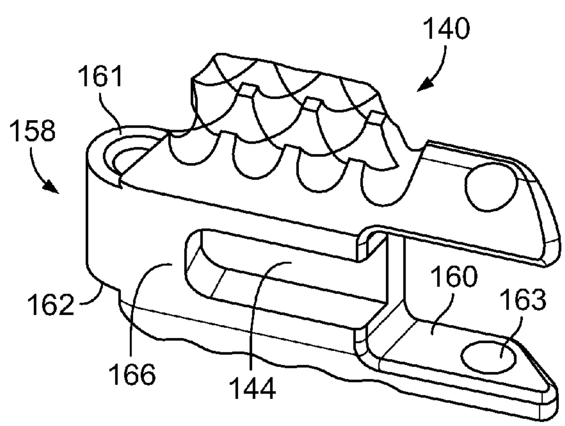

FIG. 31

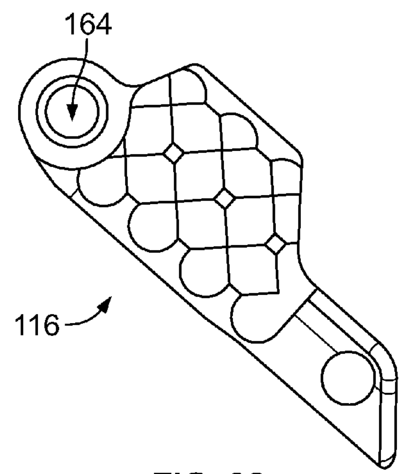

FIG. 32

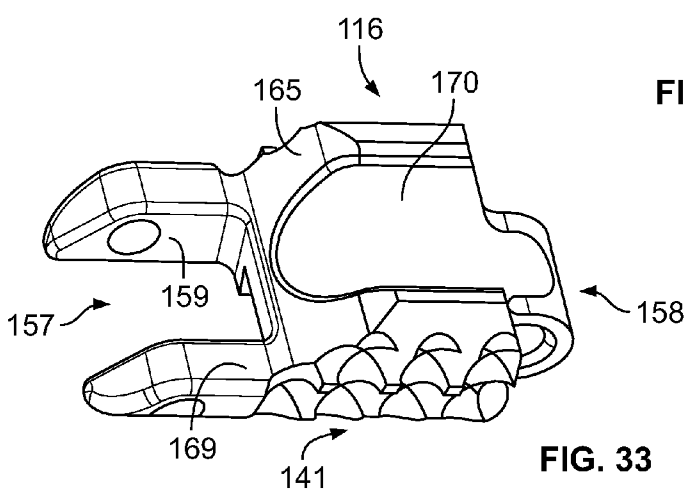

FIG. 33

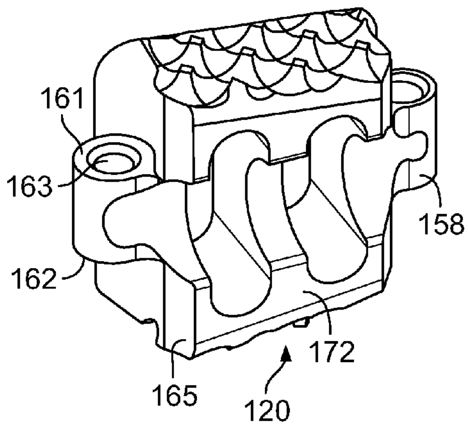

FIG. 34

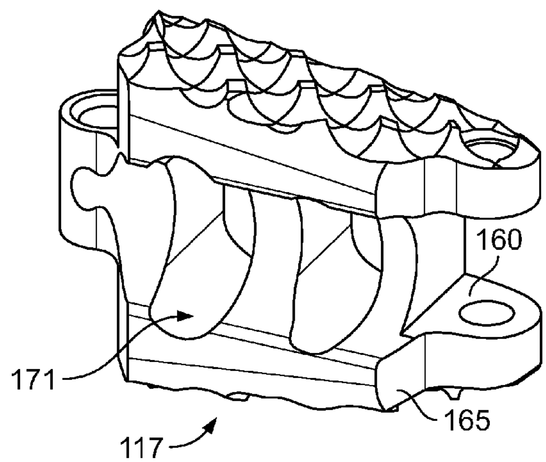

FIG. 37

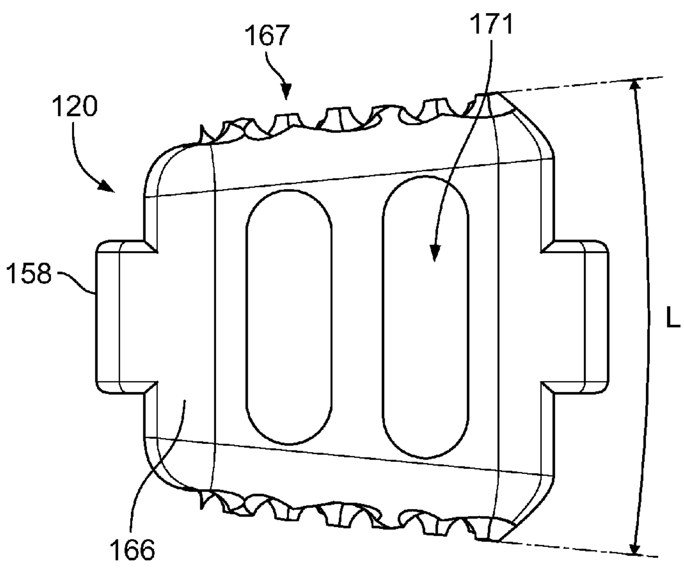

FIG. 35

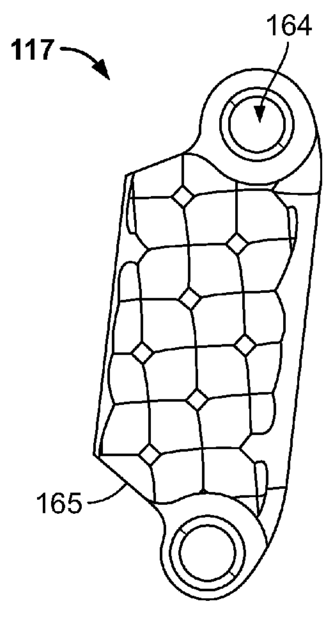

FIG. 36

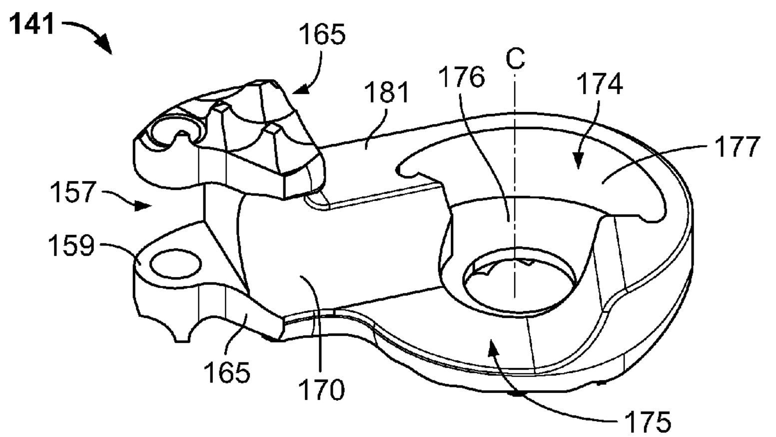

FIG. 38

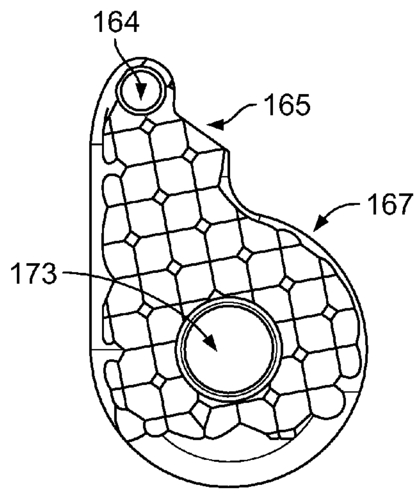

FIG. 39

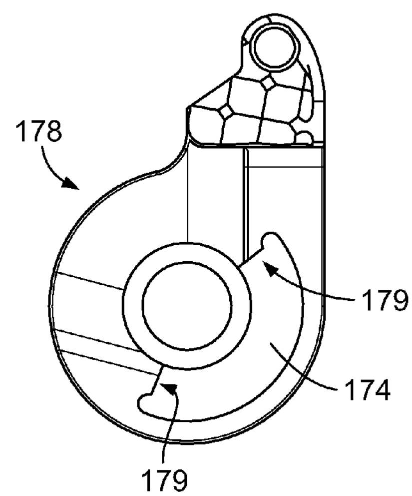

FIG. 40

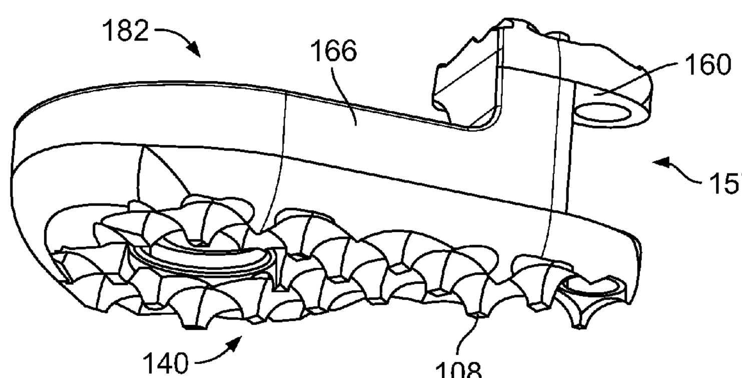

FIG. 41

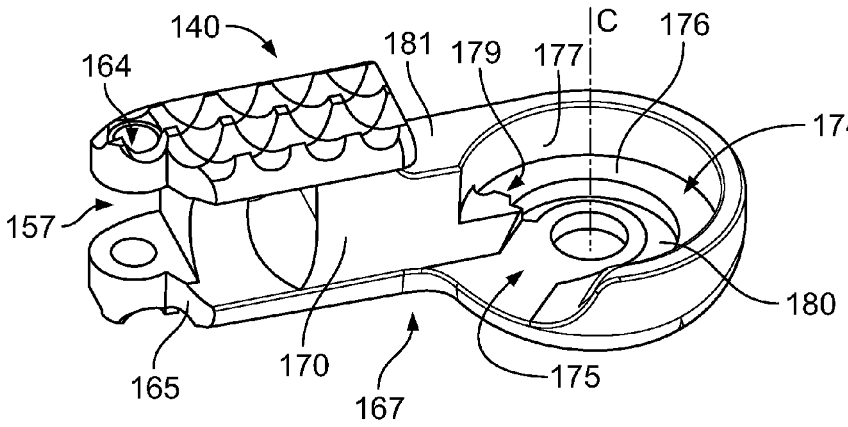

FIG. 42

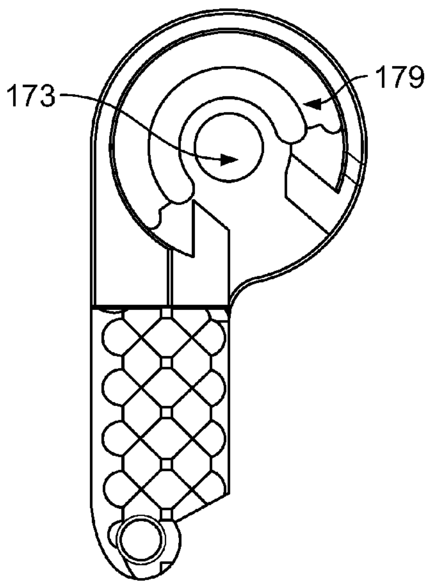

FIG. 43

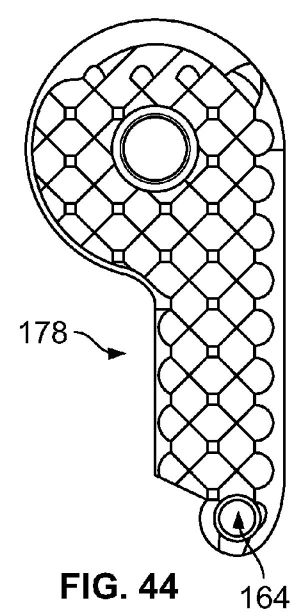

FIG. 44

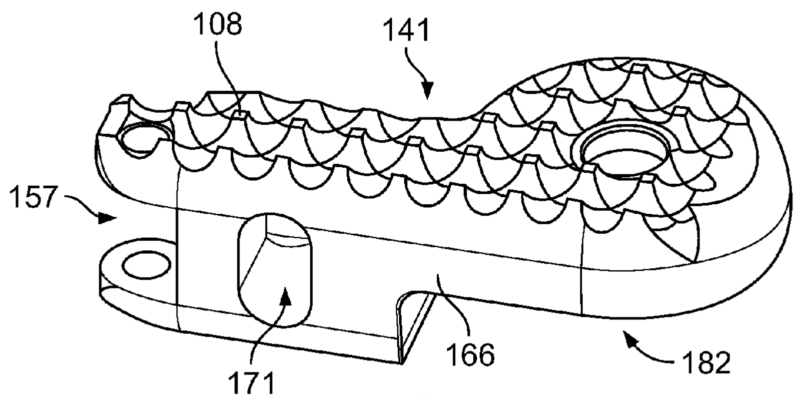

FIG. 45

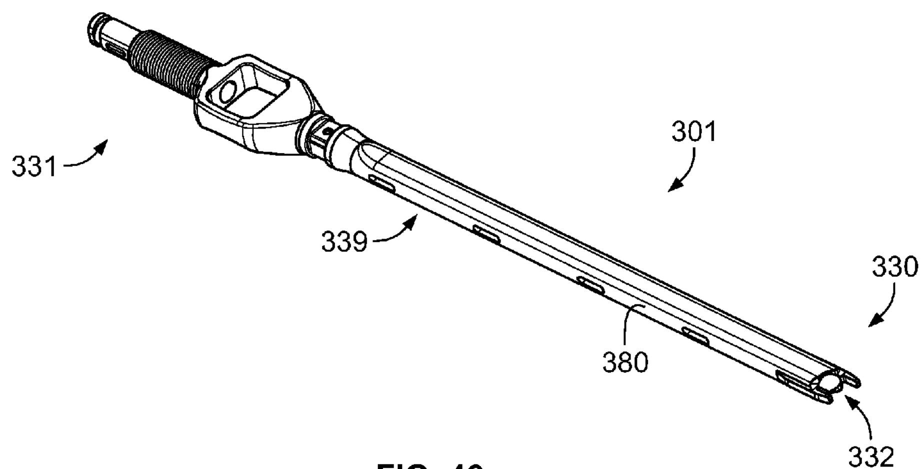

FIG. 46

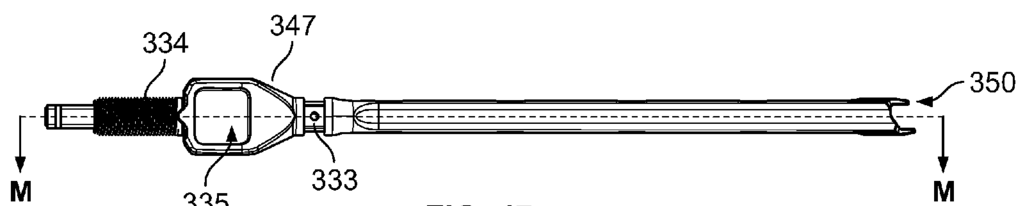

FIG. 47

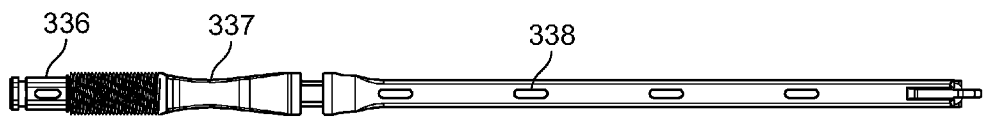

FIG. 48

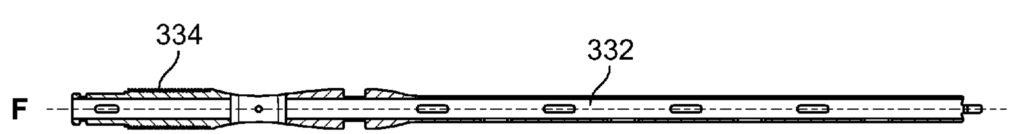

FIG. 49

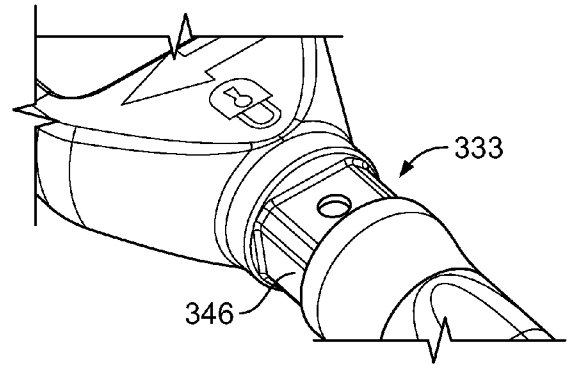

FIG. 50

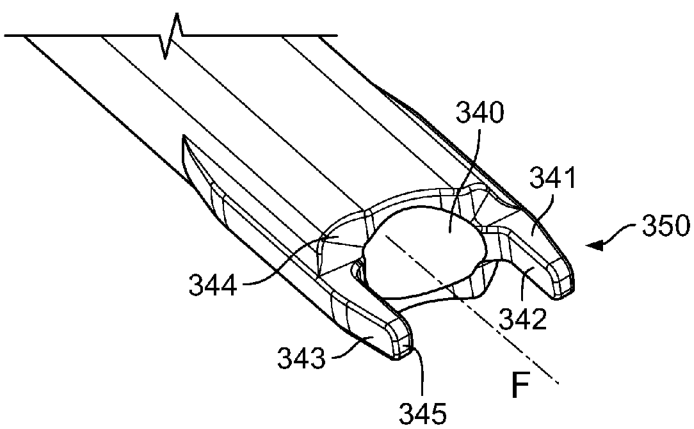

FIG. 51

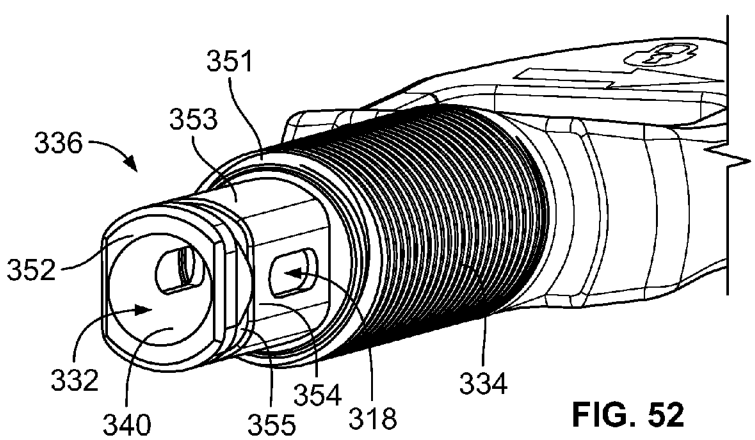

FIG. 52

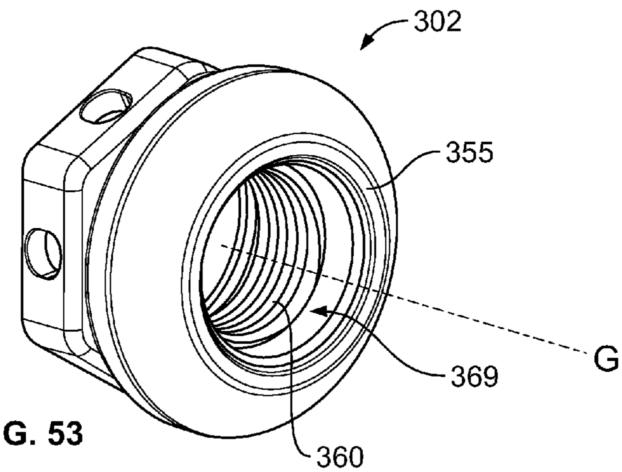
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FIG. 53

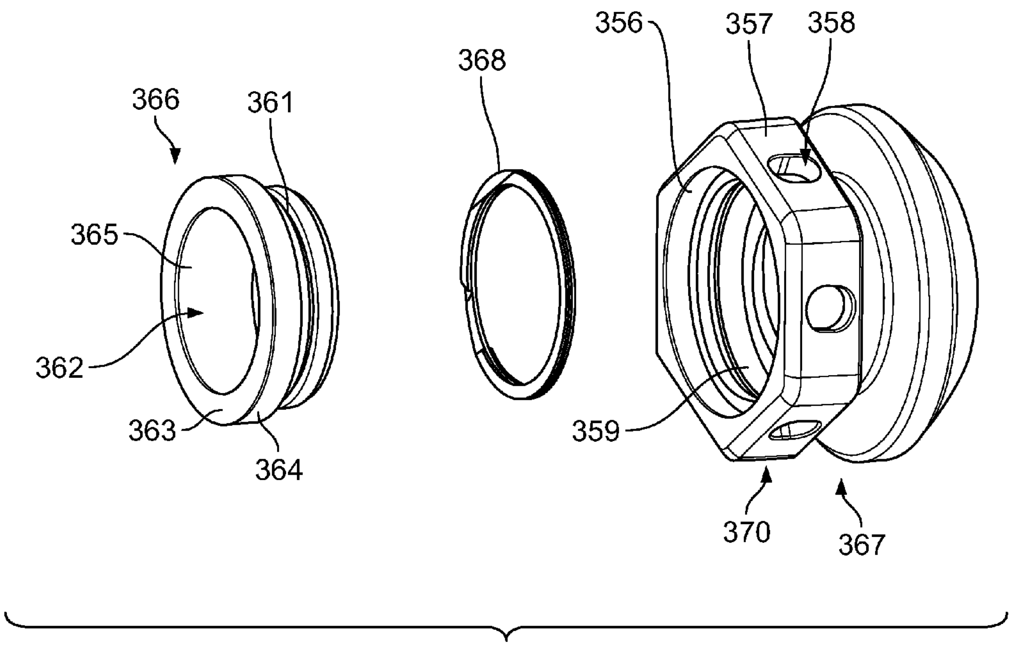
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FIG. 54

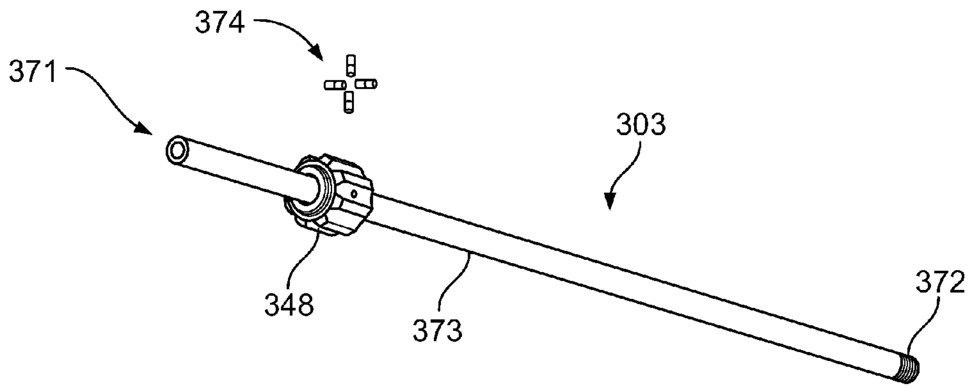

FIG. 55

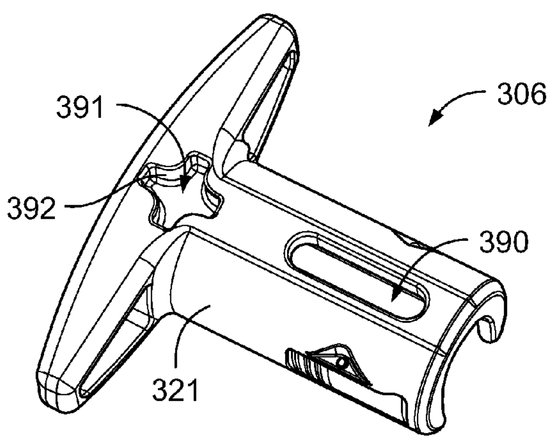

FIG. 56

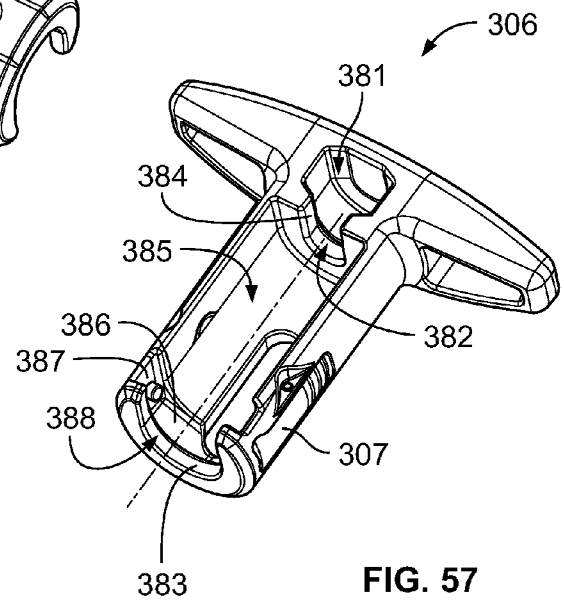

FIG. 57

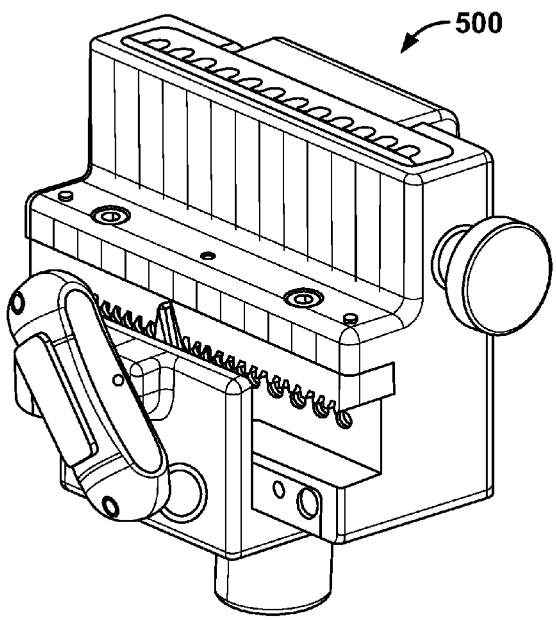

FIG. 58

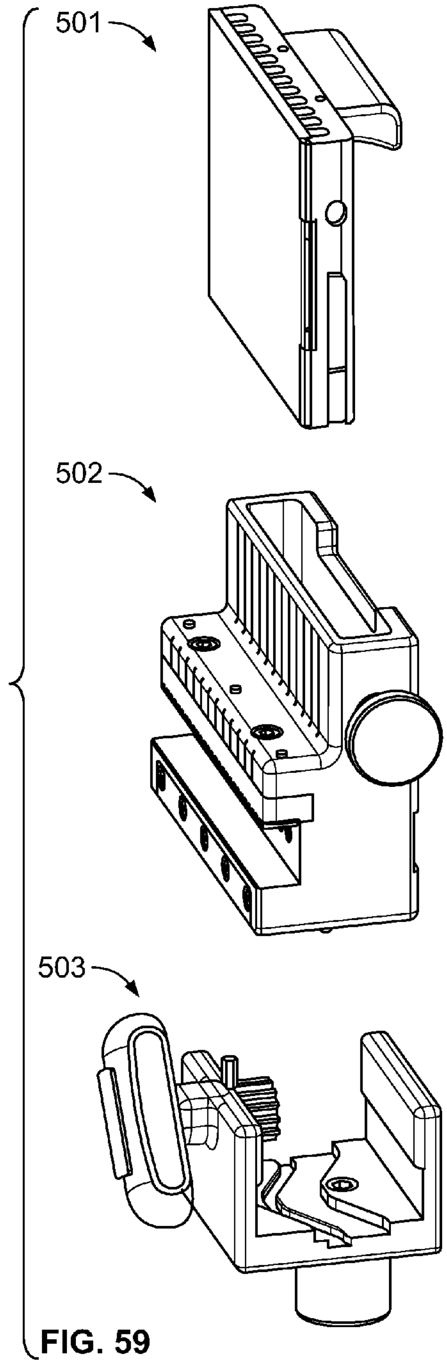

FIG. 59

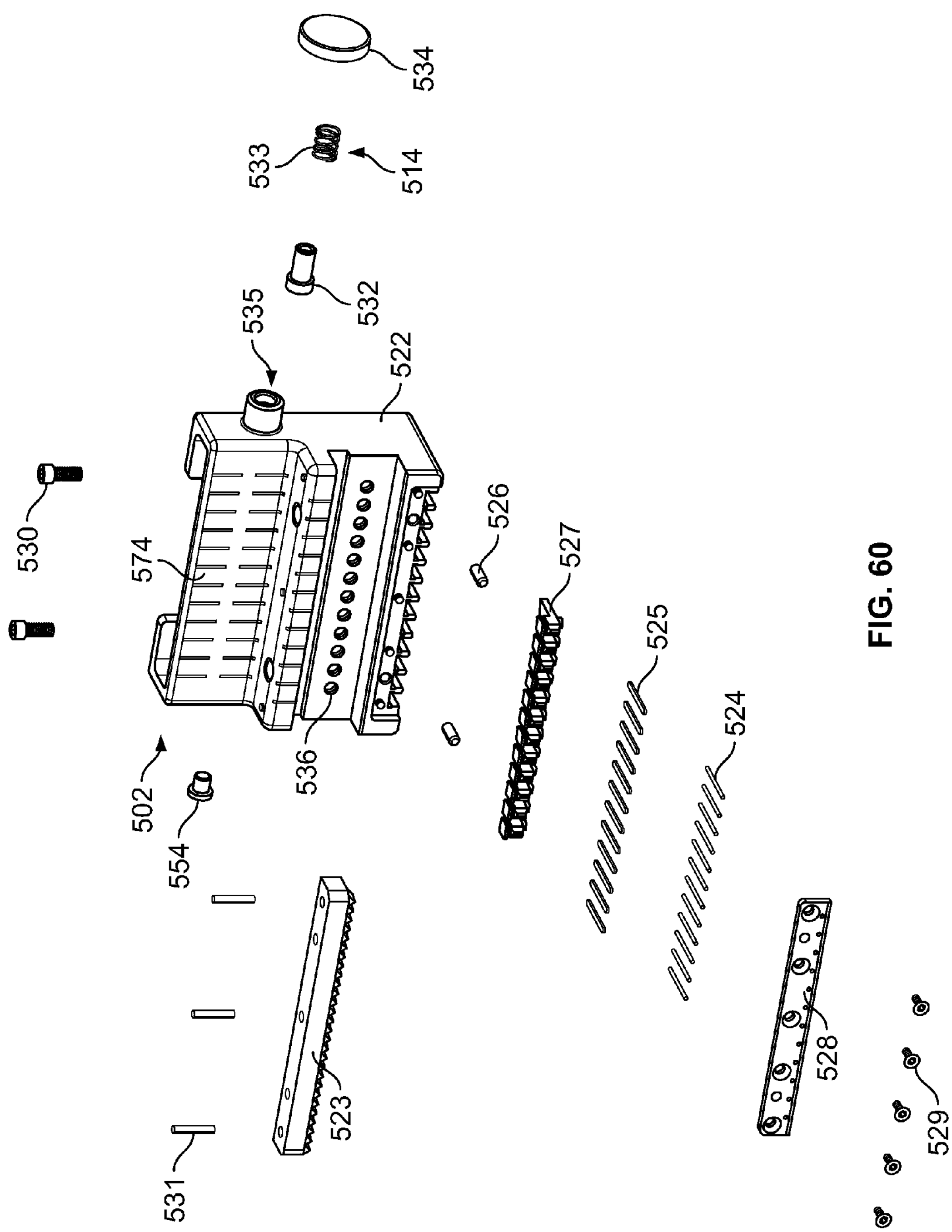
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FIG. 60

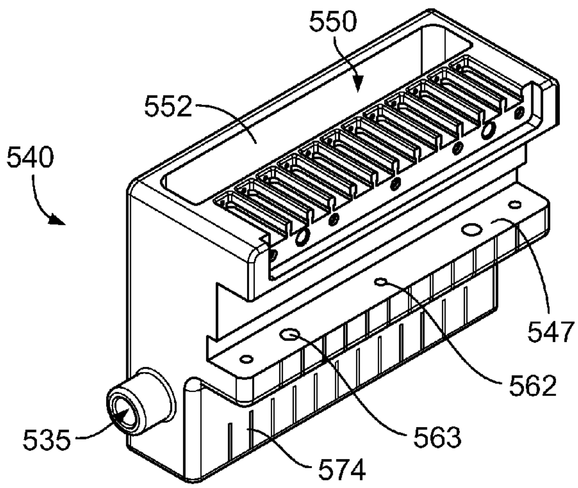

FIG. 61

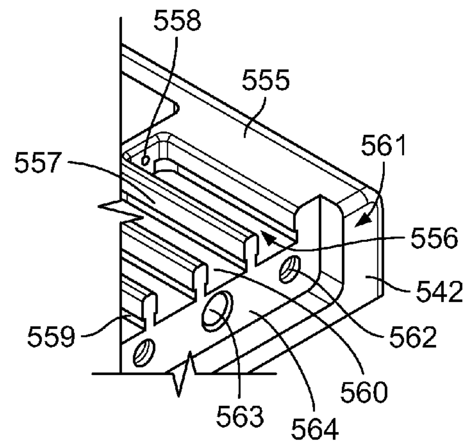

FIG. 62

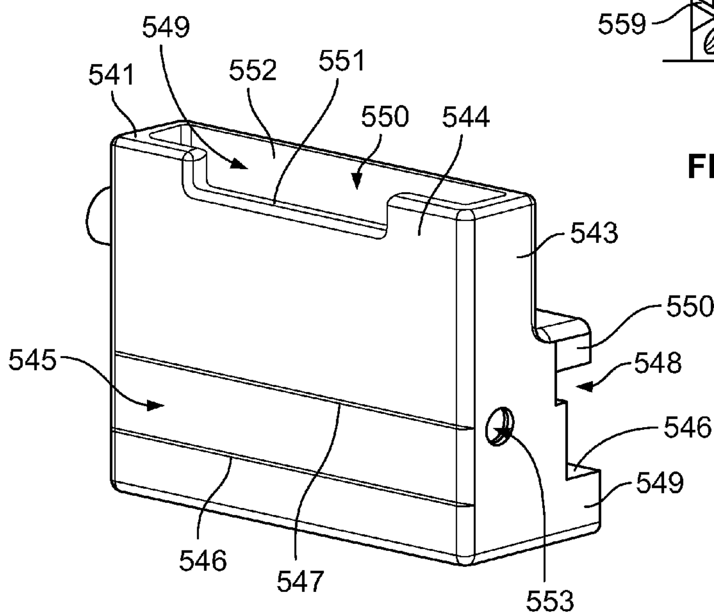

FIG. 63

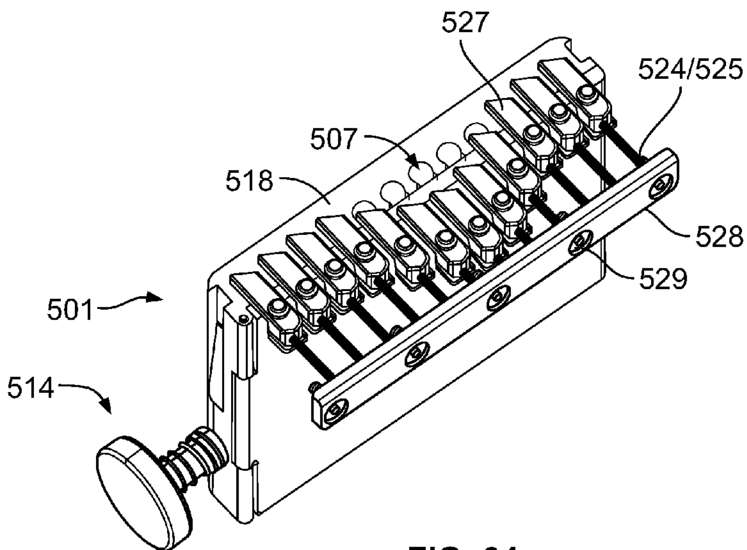

FIG. 64

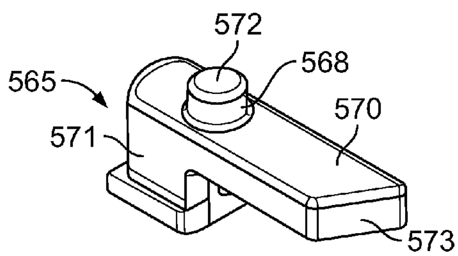

FIG. 65A

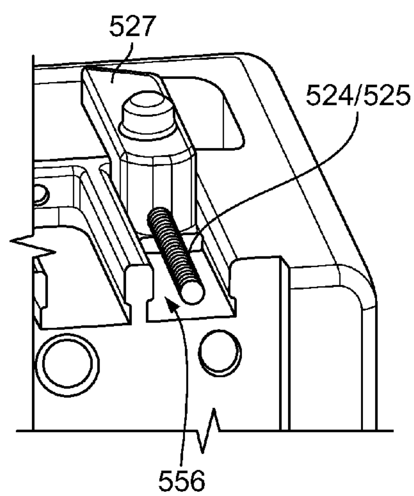

FIG. 65C

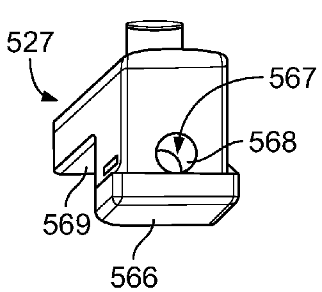

FIG. 65B

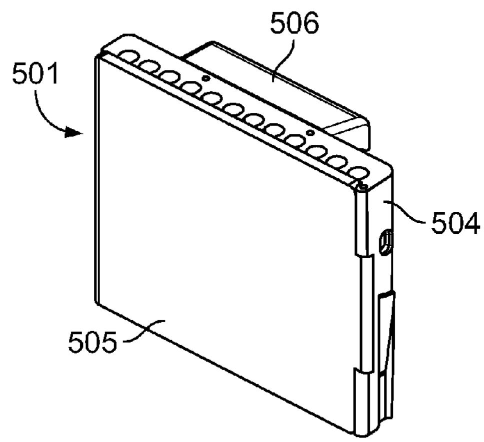

FIG. 66

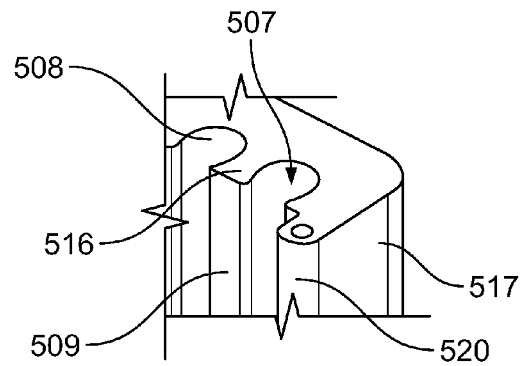

FIG. 67

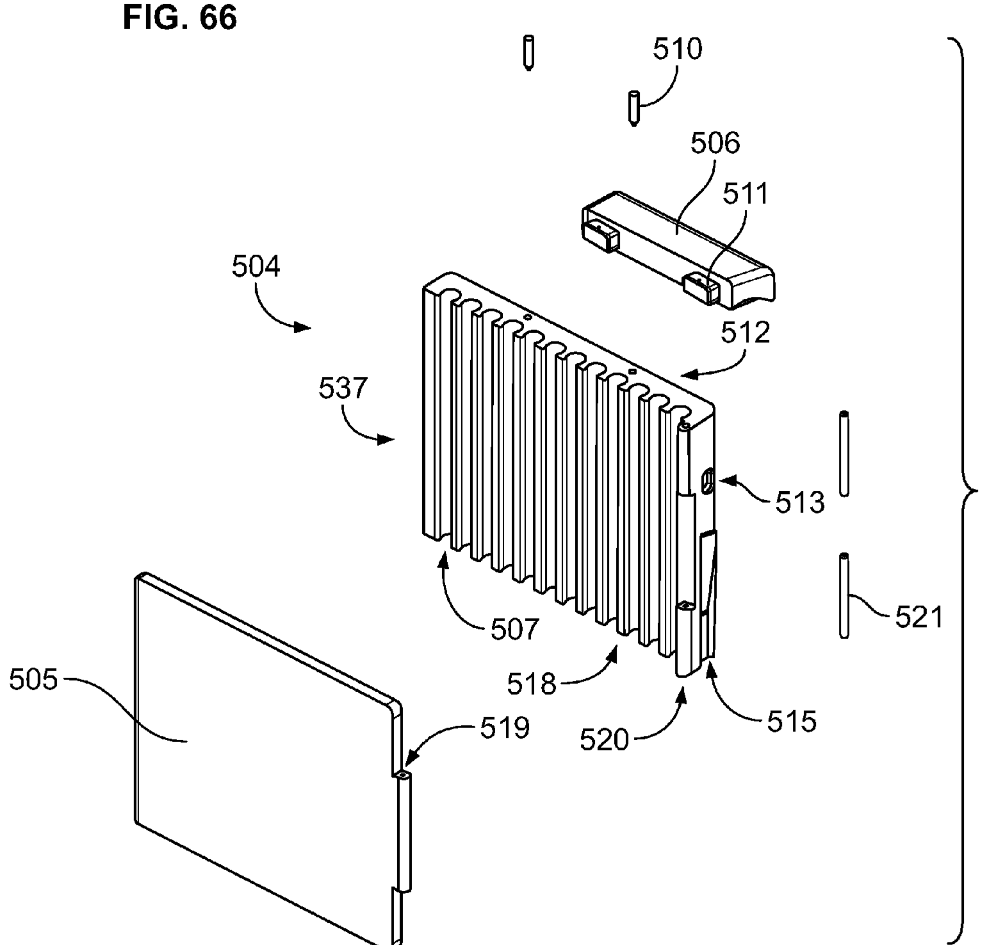

FIG. 68

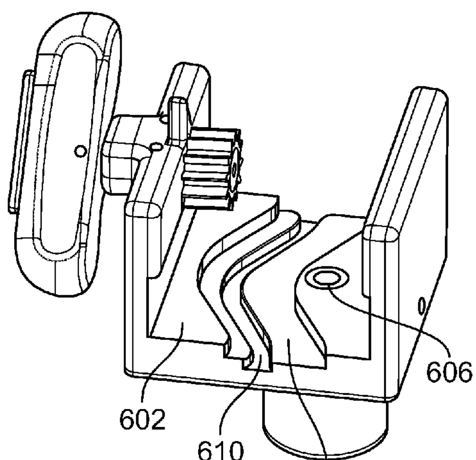
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FIG. 70

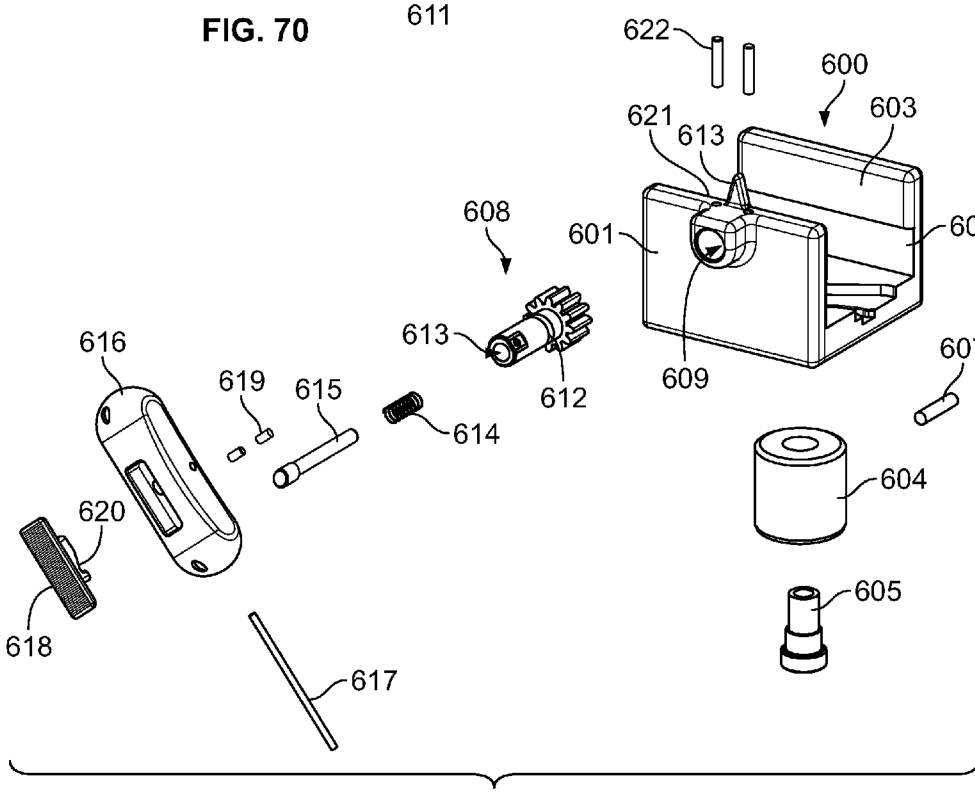
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FIG. 69

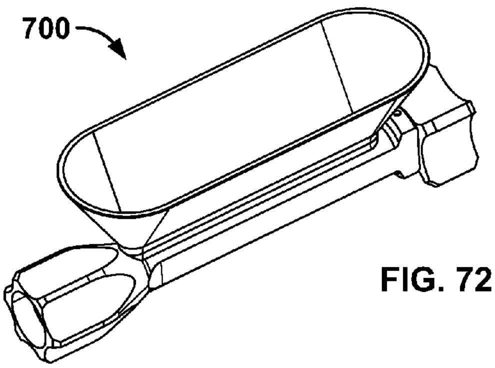
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FIG. 72

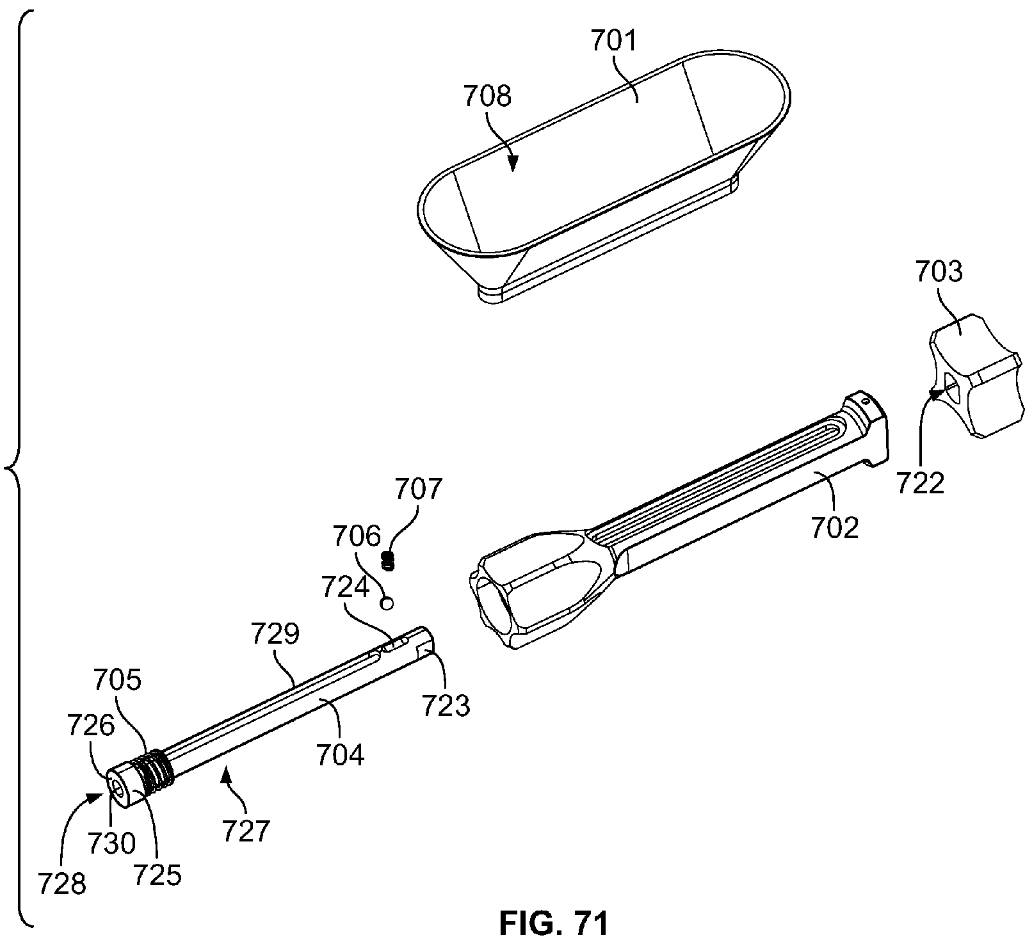
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FIG. 71

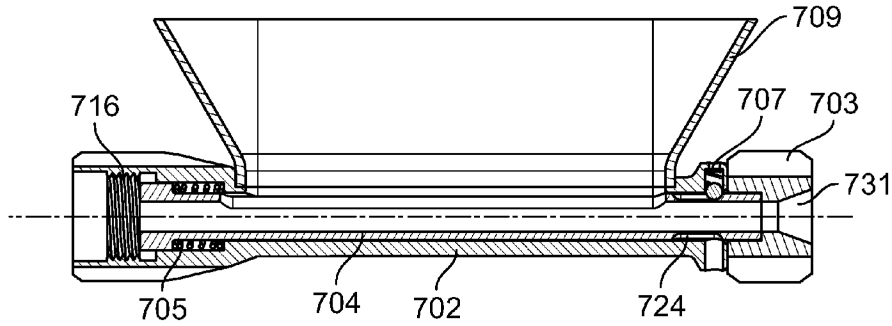


FIG. 76

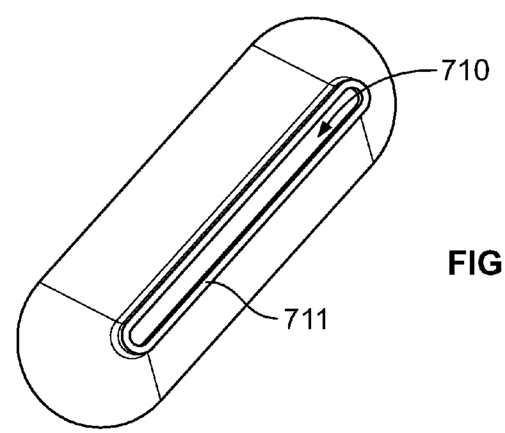


FIG. 73

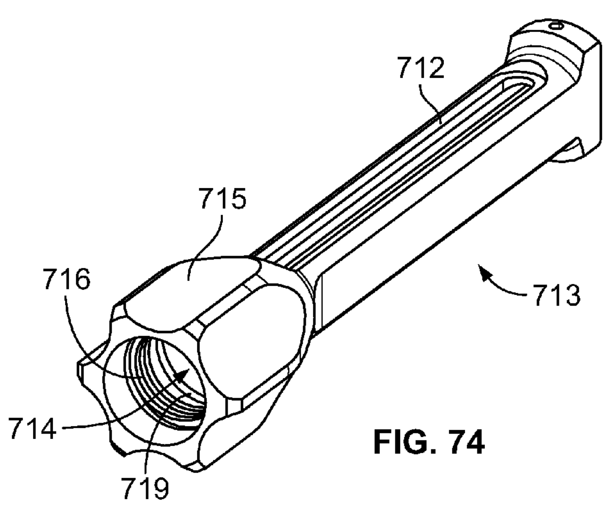


FIG. 74

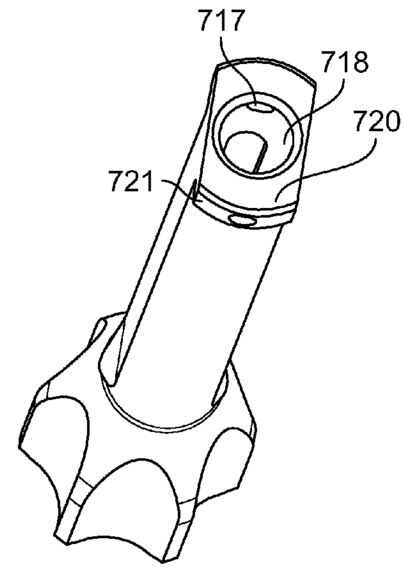


FIG. 75

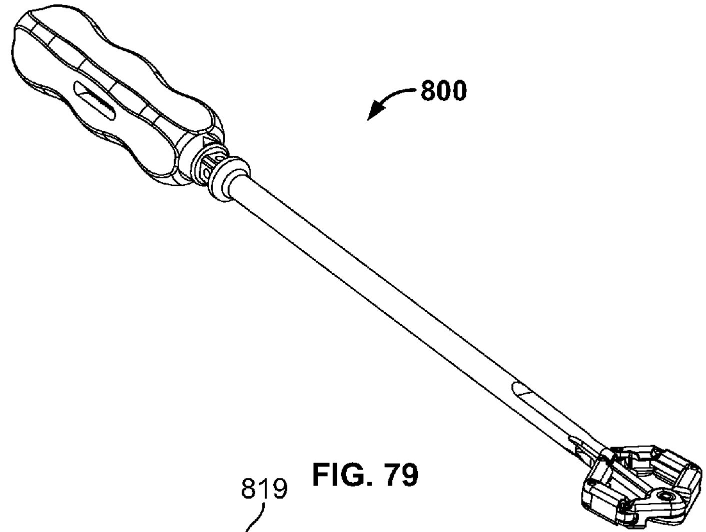


FIG. 79

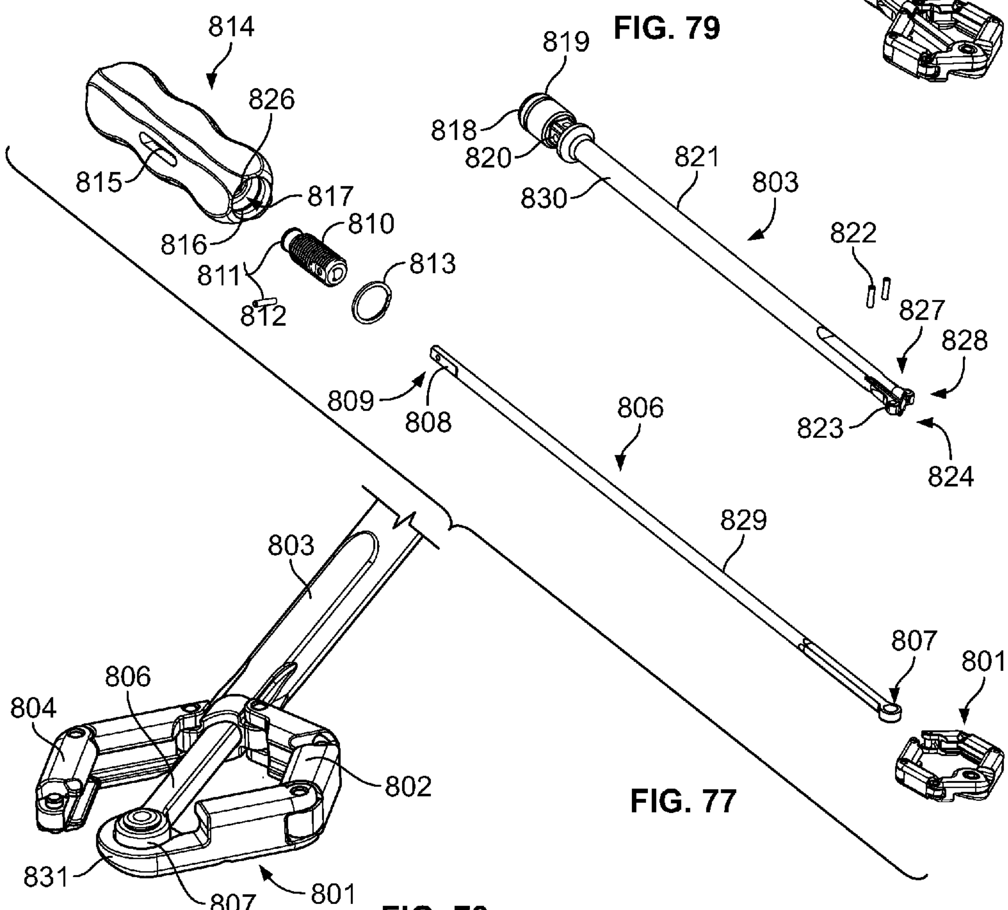


FIG. 77

FIG. 78

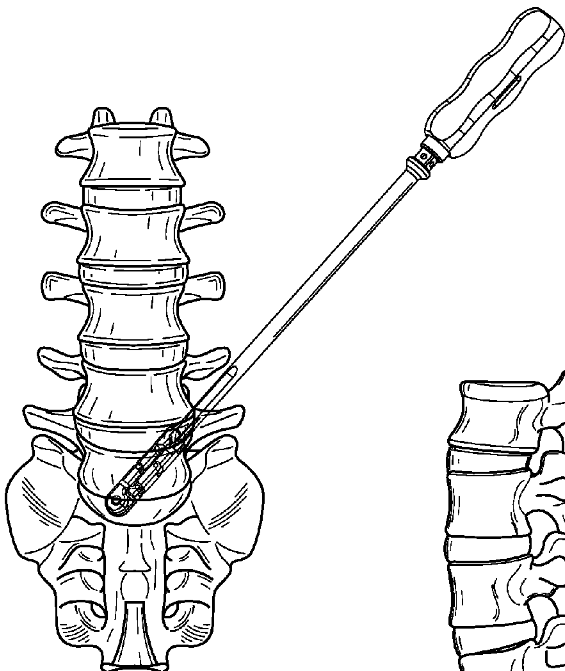


FIG. 80

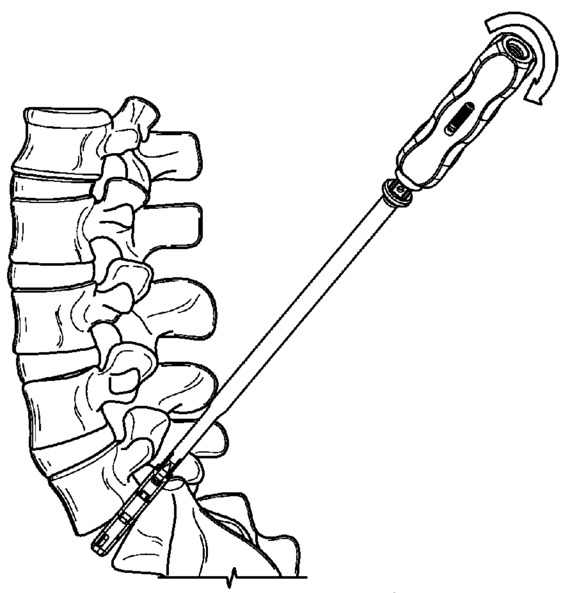


FIG. 81

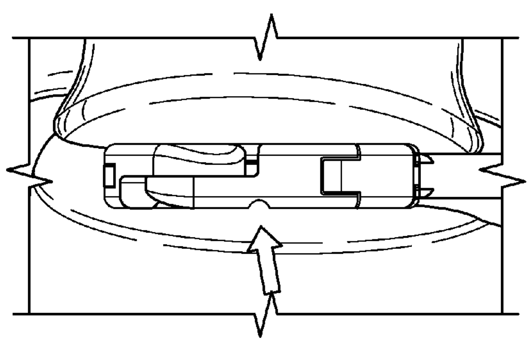


FIG. 82A

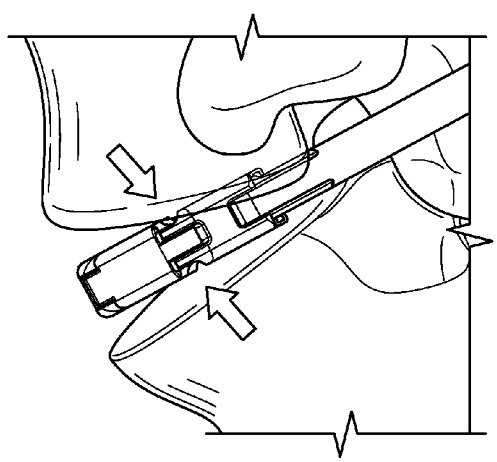


FIG. 82B

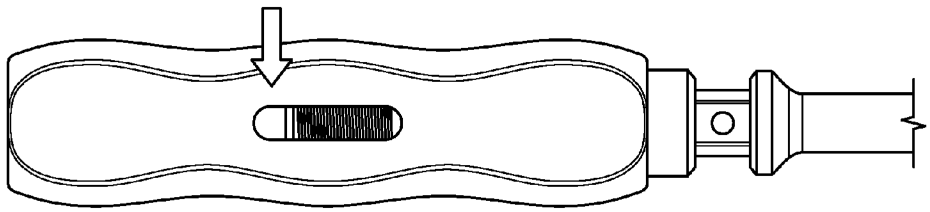


FIG. 83

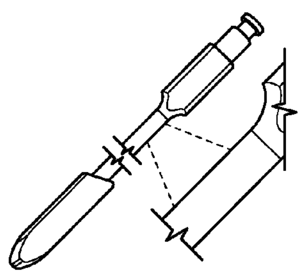


FIG. 84A

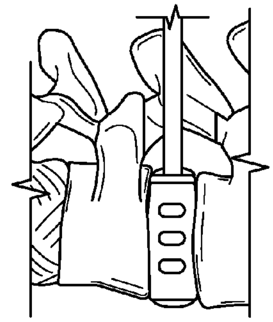


FIG. 84B

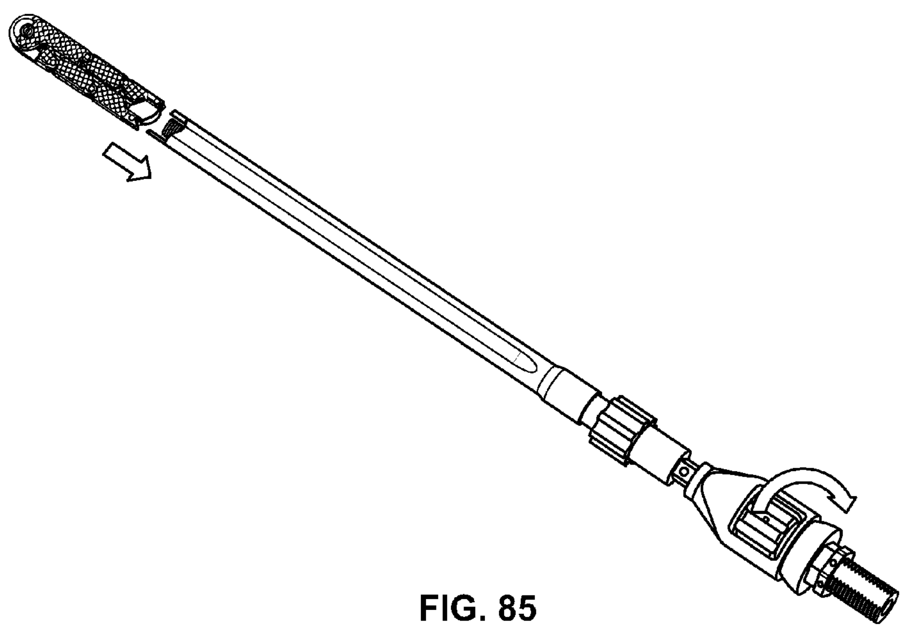


FIG. 85

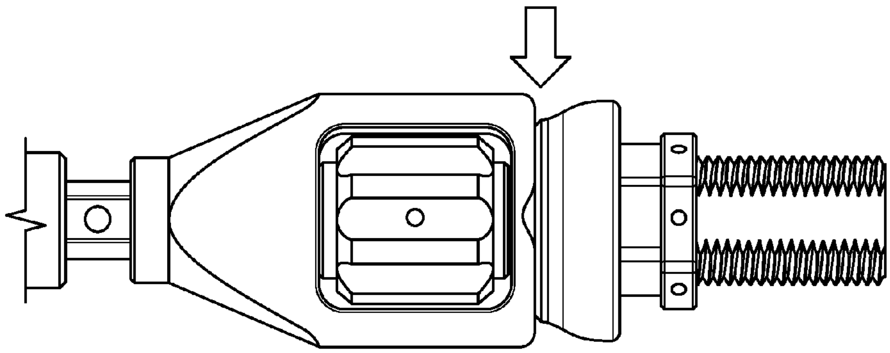


FIG. 86

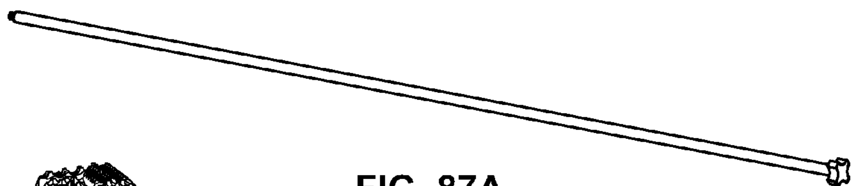


FIG. 87A

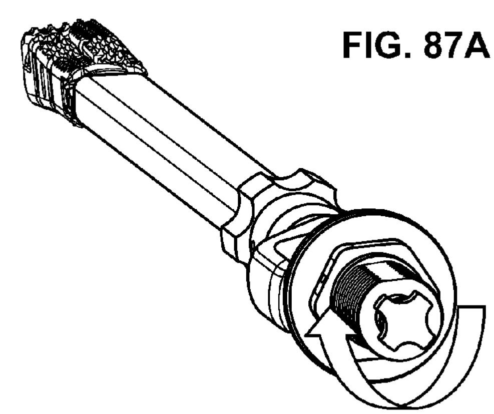


FIG. 87B

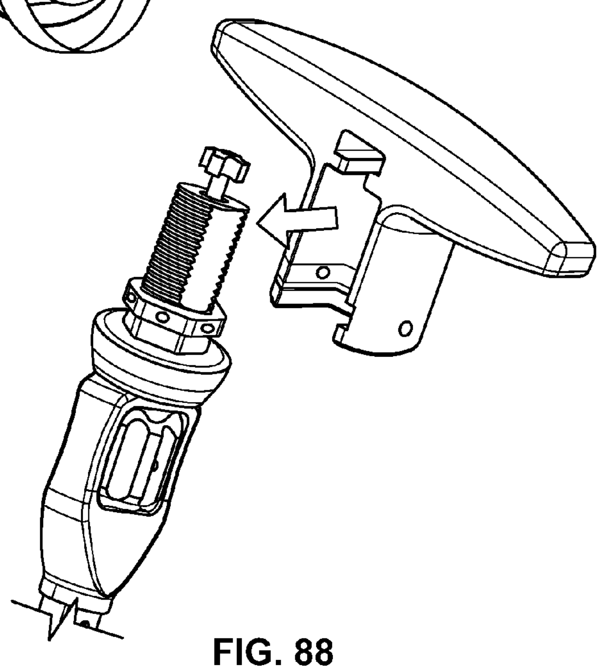


FIG. 88

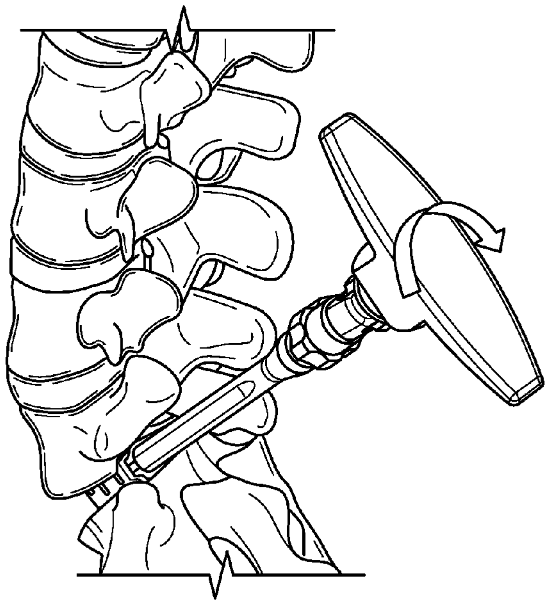


FIG. 89

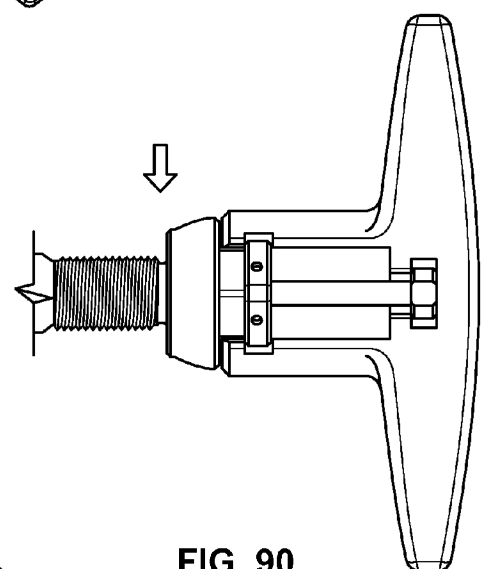


FIG. 90

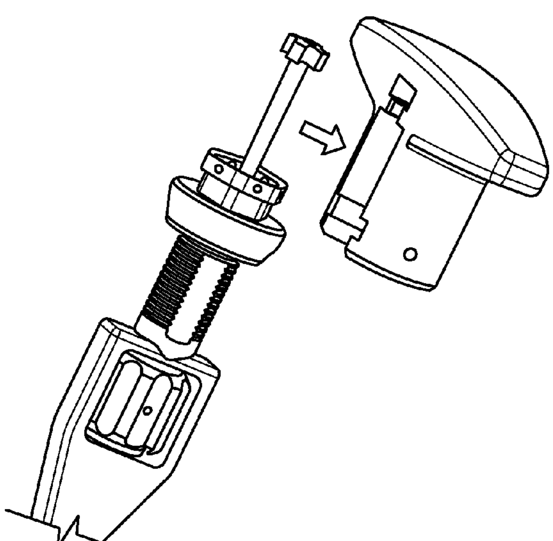


FIG. 91

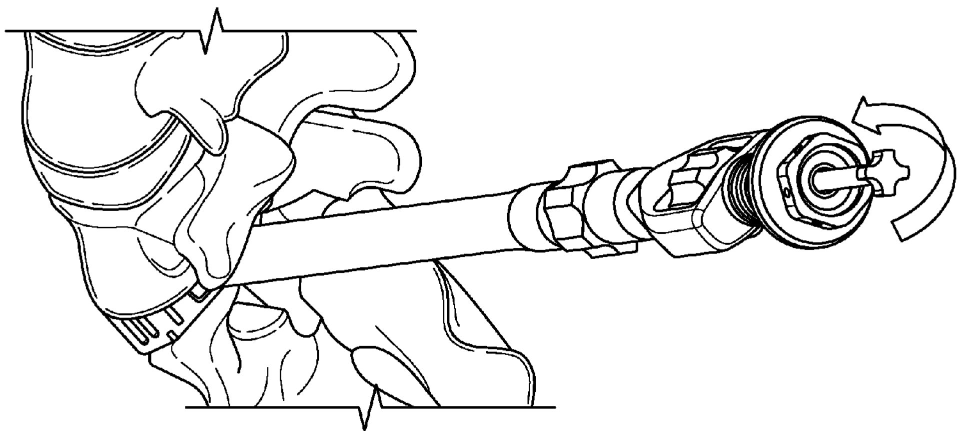
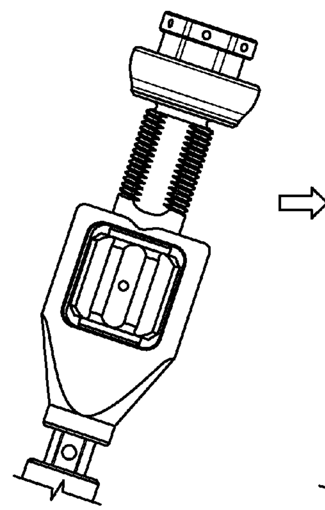


FIG. 92



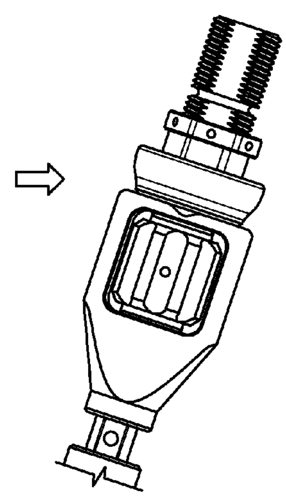


FIG. 93A

FIG. 93B

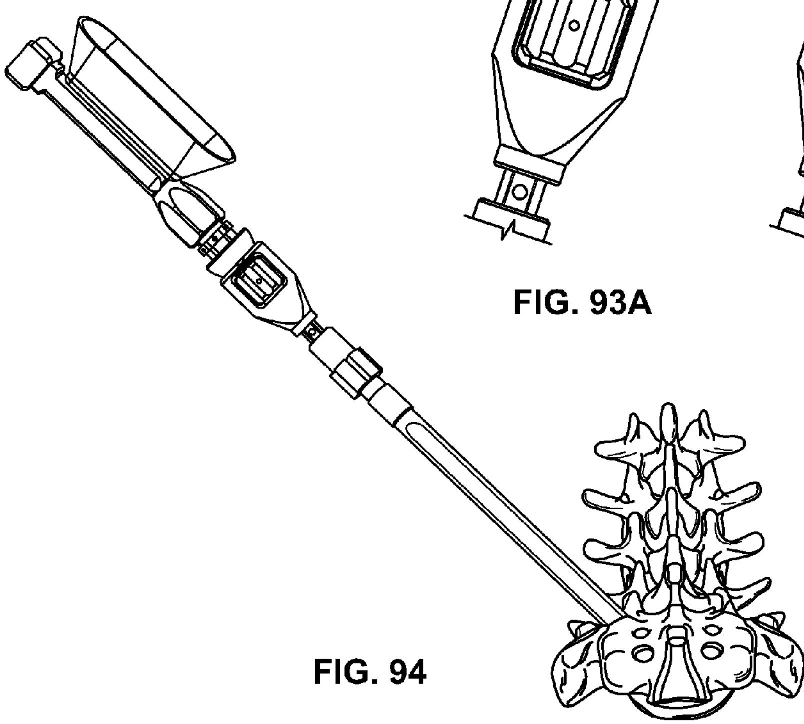


FIG. 94

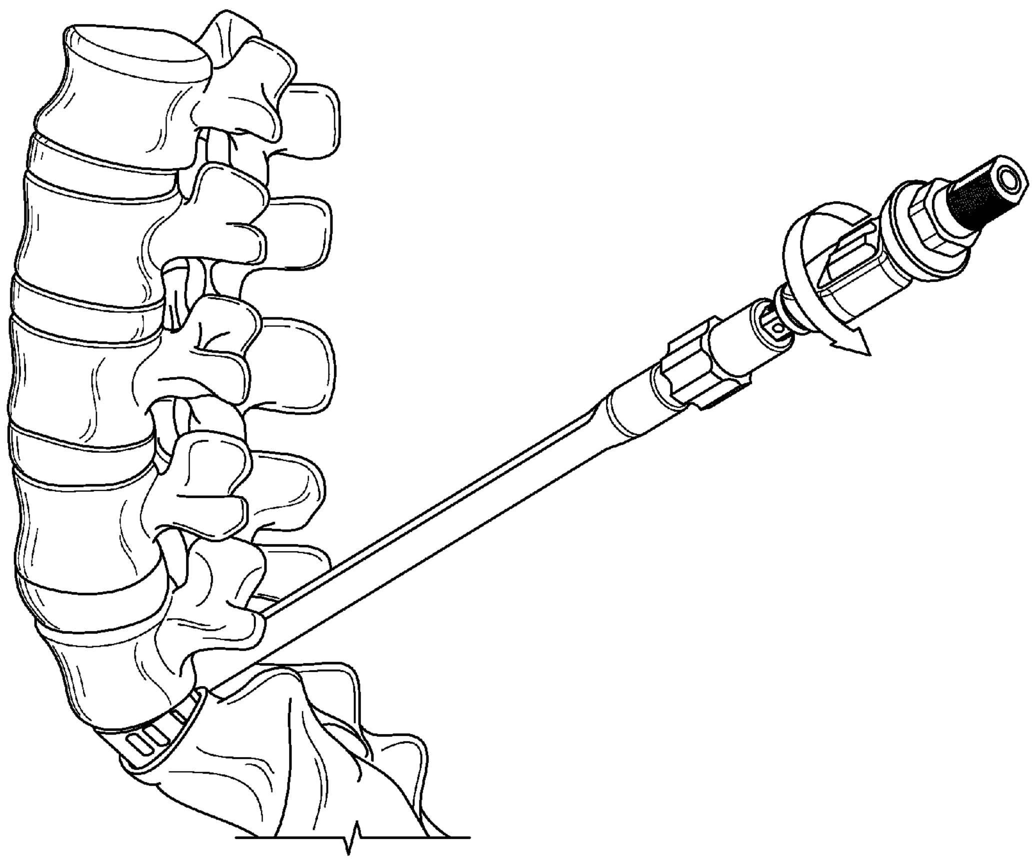


FIG. 95

EXPANDABLE SPINAL FUSION IMPLANTS AND RELATED INSTRUMENTS AND METHODS

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of the filing date of U.S. Provisional Patent Application Nos. 61/717,003, which was filed on Oct. 22, 2012, and 61/793,626 which was filed on Mar. 15, 2013. The contents of U.S. Application Nos. 61/717,003 and 61/793,626 are incorporated by reference as part of this application.

FIELD

This application relates generally to an intervertebral spacer and specialized instruments for choosing the correct size of implant, implanting the device within the intervertebral space, and for delivery of bone graft or bone substitute to the interior of the implant.

SUMMARY

The implant utilizes a plurality of joints between links of interbody spacer segments which in an insertion configuration assumes a collapsed elongate form for minimally invasive insertion down a narrow surgical corridor. The device expands to a larger footprint size in an implanted or expanded configuration at the predetermined site. In the implanted configuration, the implant is roughly the profile of the removed intervertebral disc and therein provides spacer support near the periphery of the endplate where the vertebral bone is most dense. In addition, in the implanted configuration, the spacer links define a large central aperture for packing of graft material.

A spacer template is disclosed to assist the surgeon is choosing the correct implant size but also to help validate that the disc space has been properly prepared through removal of soft tissue that may impede the final spacer from transitioning to the expanded configuration. The implant and instruments include a system and method for the insertion of the device and for the controlled transition from the insertion configuration to the implanted configuration once the device is presented in its predetermined location between the vertebral bodies. This includes mechanisms for controlling the profile of the links to prevent formation into undesired profiles in the intervertebral space and mechanisms to maintain a preferred shape once the device reaches a fully implanted configuration.

The insertion instrument also shares a minimally invasive elongated profile for use down a narrow surgical path. This instrument not only serves to attach, control and steer the implant into its predetermined location, it also controls the device's transition from the insertion configuration to the expanded implanted configuration and comprises features to prevent over expansion of the device. In addition, the instrument comprises features for attachment of a bone graft administration device and for directing the bone graft down a cannula in the instrument into the bone graft aperture defined by the expanded spacer links between the endplates. In cases in which the surgeon desires to remove the device after implantation, the instrument is also configured for reattachment and for transitioning the implant device from an implanted configuration back to an insertion configuration. Methods for implant size selection, implant insertion, transition to an implanted configuration, bone graft administration, and removal are disclosed in detail in later paragraphs.

In a preferred form, the implant device is well suited for minimally invasive insertion into the intervertebral space through a transforaminal surgical approach.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a front perspective view of an exemplary embodiment of an inserter attached to an expandable implant in its insertion configuration.

FIG. **2** is a partially exploded perspective view of the implant and inserter illustrated in FIG. **1**.

FIG. **3** is a distal end perspective view of the implant and inserter illustrated in FIG. **1**.

FIG. **4** is a partially exploded perspective view of the proximal end of the inserter illustrated in FIG. **1**.

FIG. **5** is a proximal end perspective view of an exemplary embodiment of an expandable interbody implant in its insertion configuration.

FIG. **6** is a lead end view of the expandable implant illustrated in FIG. **5**.

FIG. **7** is a side view of the expandable implant illustrated in FIG. **5**.

FIG. **8**A is a proximal end perspective view of the bottom of an exemplary embodiment of an expandable spacer in its implanted configuration.

FIG. **8**B is a superior view illustrating an expanded spacer resting on a vertebral endplate.

FIG. **9** is a posterior view of an expandable spacer adjusted for lordotic angle illustrating a decreasing height from anterior to posterior.

FIG. **10** is a top view of the implant illustrated in FIG. **8**.

FIG. **11** is an exploded perspective view of the implant illustrated in FIG. **8**.

FIG. **12** is a front perspective view of an exemplary embodiment of a fastener pivot assembly.

FIG. **13** is a cross-sectional view of the fastener pivot assembly illustrated in FIG. **12**.

FIG. **14** is a front perspective view of an alternative coupling device.

FIG. **15** is a top close up perspective view of teeth utilized on the endplate facing surface of the spacer.

FIG. **16** is a front perspective view of an exemplary embodiment of a coupling device.

FIG. **17** is a top view of the coupling device illustrated in FIG. **16**.

FIG. **18** is a front perspective view of an exemplary embodiment of a pivot coupler assembly.

FIG. **19** is a top perspective view of an exemplary embodiment of a positioner gear.

FIG. **20** is a bottom perspective view of the positioner gear illustrated in FIG. **19**.

FIG. **21** is a rear perspective view of an exemplary embodiment of a positioner gear with integrated spring.

FIG. **22** is a front perspective view of an exemplary embodiment of a positioner gear assembly.

FIG. **23** is a rear perspective view of a positioner coupling assembly.

FIG. **24** is a rear perspective view of an alternative embodiment of a positioner gear with integrated spring.

FIG. **25** is a proximal perspective view of an exemplary embodiment of an insertion link.

FIG. **26** is a top view of the inserter link of FIG. **25**.

FIG. **27** is a proximal view of the inserter link of FIG. **25**.

FIG. **28** is a front perspective view of an exemplary embodiment of a lateral proximal link of the implant.

FIG. **29** is a top view of the link of FIG. **28**.

FIG. **30** is a rear perspective view of the link of FIG. **28**.

FIG. **31** is a front perspective view of a medial proximal link of the implant.

FIG. **32** is a top perspective view of the implant illustrated in FIG. **31**.

FIG. **33** is a rear perspective view of the implant illustrated in FIG. **31**.

FIG. **34** is an inside perspective view of a lateral intermediate link of the implant.

FIG. **35** is an outside view of the link illustrated in FIG. **34** and illustrating lumbar angle L.

FIG. **36** is a top view of the link illustrated in FIG. **34**.

FIG. **37** is an inside perspective view of an exemplary embodiment of a medial intermediate link of the implant.

FIG. **38** is an inside perspective view of an exemplary embodiment of a medial distal link of the implant.

FIG. **39** is a bottom view of the medial distal link illustrated in FIG. **38**.

FIG. **40** is a top view of the medial distal link illustrated in FIG. **38**.

FIG. **41** is an outside perspective view of the medial distal link illustrated in FIG. **38**.

FIG. **42** is an inside perspective view of an exemplary embodiment of a lateral distal link of the implant.

FIG. **43** is a top view of the lateral distal link illustrated in FIG. **42**.

FIG. **44** is a bottom view of the lateral distal link illustrated in FIG. **42**.

FIG. **45** is an outside perspective view of the lateral distal link illustrated in FIG. **42**.

FIG. **46** is a front perspective view of an exemplary embodiment of the inserter's control frame.

FIG. **47** is a top view of the control frame illustrated in FIG. **46**.

FIG. **48** is a side view of the control frame illustrated in FIG. **46**.

FIG. **49** is a cross-sectional view of the control frame illustrated in FIG. **46** along axis M-M.

FIG. **50** is a top perspective close-up view of the neck portion of the control frame.

FIG. **51** is a distal end close up view of the control arms of the control frame.

FIG. **52** is a proximal end close up view of the expansion limiter mount.

FIG. **53** is front perspective view of an exemplary embodiment of the handle collar assembly.

FIG. **54** is an exploded view of the handle collar assembly illustrated in FIG. **53**.

FIG. **55** is a front perspective view of an exemplary embodiment of a fixation tube with lockwheel and fixators.

FIG. **56** is a rear perspective view of an exemplary embodiment of an expansion handle.

FIG. **57** is a front perspective view of the expansion handle illustrated in FIG. **56**.

FIG. **58** is a front perspective view of an exemplary embodiment of a graft inserter assembly.

FIG. **59** is an exploded view of 3 components of the graft inserter assembly illustrated in FIG. **58**.

FIG. **60** is an exploded view of a cartridge retainer portion of graft inserter assembly of FIG. **58**.

FIG. **61** is a bottom perspective view of a cartridge retainer housing body.

FIG. **62** is a bottom perspective close up view of chute door recesses of cartridge retainer housing body.

FIG. **63** is a rear perspective view of a cartridge retainer housing body.

FIG. **64** is a bottom perspective view of the graft inserter assembly with selected portions removed to illustrate the functional interaction between the chutes and chute doors.

FIG. **65**A is a bottom perspective view of a chute door.

FIG. **65**B is a rear perspective view of a chute door.

FIG. **65**C is a close-up perspective view of a chute door residing in a chute door recess.

FIG. **66** is a front perspective view of a graft cartridge portion of graft inserter assembly of FIG. **58**.

FIG. **67** is a front perspective closeup view of the chutes of the graft cartridge portion.

FIG. **68** is an exploded view of a graft cartridge portion.

FIG. **69** is an exploded view of a graft delivery guide portion of the graft inserter assembly illustrated in FIG. **58**.

FIG. **70** is a top perspective view of a graft delivery guide portion of the graft inserter assembly.

FIG. **71** is an exploded view of a graft funnel.

FIG. **72** is a top perspective view of a graft funnel.

FIG. **73** is a bottom perspective view of a funnel portion of a graft funnel.

FIG. **74** is distal perspective view of a collector tube portion of the graft funnel illustrated in FIG. **72**.

FIG. **75** is a proximal perspective view of a plunger tube of the graft funnel illustrated in FIG. **72**.

FIG. **76** is a cross-sectional view of the graft funnel illustrated in FIG. **72**.

FIG. **77** is an exploded perspective view of an exemplary embodiment of the spacer template instrument illustrated in FIG. **79**.

FIG. **78** is a close-up view of template spacer portion of the spacer template instrument illustrated in FIG. **79** with a link removed for viewing of expansion rod coupler.

FIG. **79** is a front perspective view of an exemplary embodiment of a spacer template instrument.

FIG. **80** is an anterior view of the spacer template inserted in the disc space.

FIG. **81** is a lateral view illustrating expansion of the spacer template.

FIG. **82**A illustrates from an anterior view notch alignment indicating full expansion of the spacer template.

FIG. **82**B illustrates from a lateral view notch alignment indicating full expansion of the spacer template.

FIG. **83** illustrates full expansion of a spacer template as indicated on the handle by the arrow pointing to green indicator is proximal to the slot.

FIG. **84**A illustrates a paddle sizer.

FIG. **84**B illustrates use of a paddle sizer inserted in the disc space.

FIG. **85** illustrates sliding spacer on to the control arms of the insertion instrument and advancing fixation tube threads to secure spacer to the insertion instrument.

FIG. **86** illustrates pre-setting of the handle collar assembly on the control frame by the arrow pointing to no gap between rotating collar and inserter.

FIG. **87**A illustrates an expansion rod.

FIG. **87**B illustrates threading of the expansion rod through inserter and into coupler link.

FIG. **88** illustrates mounting expansion handle over the handle collar.

FIG. **89** illustrates rotation of the expansion handle to transition spacer to expanded configuration.

FIG. **90** illustrates confirmation of full spacer expansion as indicated by indicia on control frame by the arrow pointing to green indicator appears below collar.

FIG. **91** illustrates removal of expansion handle from handle collar.

FIG. **92** illustrates derotation of expansion rod to release it from the coupler for removal.

FIG. **93**A and FIG. **93**B illustrate re-setting the handle collar assembly.

FIG. **94** illustrates the graft funnel inserted on the inserter.

FIG. **95** illustrates derotation of the lockwheel for removal of the instruments from the spacer.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** illustrates an exemplary embodiment of an expandable spacer and insertion assembly **101** with the spacer **100** in its insertion configuration and mounted to spacer inserter **300**. FIG. **2** illustrates a partially exploded view of each portion of assembly **101** including spacer **100**, control frame **301**, handle collar **302**, fixation tube **303**, expansion rod **304**, expansion limiter **305**, and expansion handle **306**. FIG. **3** is a distal end view of assembly **101** illustrating the small diameter profile when assembly **101** is in its insertion configuration.

A closer view of spacer **100** in its insertion configuration is illustrated in FIG. **5**-**7**. The spacer **100** comprises a proximal end **102**, a distal end **103**, a lateral side **104**, a medial side **105**, and support face **107** with opposing support face **106**. Teeth **108** are inscribed on support face **106** and support face **107** and are configured to embed in the superior and inferior vertebral endplates to prevent migration of spacer **100** once the spacer is placed in its predetermined location between the vertebral bodies.

FIG. **15** illustrates teeth **108** which comprise a penetrating face **112** that is sufficiently narrow or pointed to penetrate the bone of the endplate, and positional faces **113** that upon penetration abut the bone and prevent migration across the endplate. In this embodiment, the penetrating faces **112** have a small square footprint and the positional faces **113** have a sloped rounded pyramid profile. Positional faces **113** of teeth **108** broaden as they move away from the penetrating face **112** therein increasing anti-migration strength as spacer **100** settles into the endplate. A valley face **114** seats against the bone as a limit to subsidence of the spacer **100** into the bone. Teeth **108** in this embodiment are manufactured using a rounded cutter spaced 90 degrees apart.

Leading the distal end **103** of spacer **100** is nose **109**. The nose is configured for eased entry into the intervertebral space and may include tapered **110** and/or rounded **111** surfaces to ease the spacer **100** between the vertebral bodies and by pass soft tissue during entry. In the insertion configuration, spacer **100** assumes a narrow, compact, elongated form in order to minimize the size of the incision required for entry into the intervertebral space. From a lead end view (FIG. **6**), the spacer **100** in this embodiment has a generally rectangular profile with support faces **106**, **107** longer in length than the lateral **104** and medial **105** sides. In some embodiments, the support faces **106**, **107** are sloped to fit a predetermined lumbar angle between the patient's vertebrae as can be seen in FIG. **9** wherein the anterior links of spacer **100** slope to greater heights moving towards the posterior links.

The vertebral body is strongest near the periphery of the endplate while the endplate profile is often described as oval, lima bean, or 'race track' shaped. Better fusions and overall better results are achieved when the interbody spacer is configured to rest on this dense bone near the endplate periphery while providing a large central graft aperture for the packing of bone graft. Therefore, in its expanded configuration, it is preferred that the outer perimeter of spacer **100** approximate the profile of the vertebral endplate as illustrated in FIG. **8**A. Spacer **100** is illustrated in its expanded configuration in FIGS. **8**-**10**. In this preferred embodiment, the spacer comprises seven links and forms an irregular hexagon to generally assume the outer endplate 'racetrack' profile. In other embodiments, the number of links utilized in the spacer may vary.

FIG. **11** illustrates an exploded view of spacer **100** which is comprised of a plurality of links joined by joints **130**. The links comprise insertion link **115** with central axis 'A' located at proximal end **102** of spacer **100** which serves as the site of attachment for inserter **300**. Central axis 'A' is configured to be generally collinear with the surgical access path. For example, if spacer **100** was configured for a lateral surgical approach, insertion link **115** would preferably be placed lateral with central axis 'A' directed along a lateral direction. In this preferred embodiment, spacer **100** is configured for surgical insertion into the intervertebral space along a transforaminal surgical path indicated as 'P' in FIG. **8**B. Insertion link **115** is therefore positioned posterior laterally and axis-A is directed in a posterior lateral direction. The spacer **100** in this embodiment is configured for use from either the left or right side of the spine wherein a support face **140** or **141** that faces superior when inserted from one side will face inferior when inserted from the other. Consistent with the transforaminal surgical approach, spacer **100** is inserted with a definitive medial and lateral side therein assuring alignment of the inserter link with the surgical path regardless of left or right side entry.

Joints **130** provide movement between each link portion **115**-**121** in a plane generally parallel to the intervertebral space. The joints may assume any variety of forms such as ball and socket, snap, hinge, or a pin or knuckle joint. Pin joints are utilized in the preferred embodiment and each link portion **115**-**121** comprises one or more capture tongue **158** configured to reside within a complementary capture groove **157** (FIG. **31**,**33**) on an adjacent link portion **115**-**121** to form an endless chain. In the expanded configuration, this chain of links defines a graft aperture **122** available for packing with bone graft or other bone substitute.

Each link portion **115**-**121** of spacer **100** may share a plurality of common features not necessarily labeled on each link. For example, each link is formed from a body **167**, each link except for the inserter link has teeth **108**, and link support faces **140**, **141** are common to each link and abut the endplates therein maintaining the predetermined intervertebral space. Adjacent links **115**-**121** comprise a capture groove **157** and a capture tongue **158** aligned within said groove to form a joint **130**. Two capture walls **154** & **155** define capture groove **157**. The interior of capture groove **157** comprises one or more capture surfaces **159**-**160** (FIG. **28**,**30**). Capture tongue **158** (FIG. **34**) comprises opposing guide surfaces **161** and **162**. Pin wall **163** extends vertical through capture tongue **158** and capture walls **154** & **155** therein defining pin aperture **164** with central axis-B.

Joints **130** are formed by configuring a capture tongue **158** within capture groove **157** and aligning axis-B. Pivot pins **129** are then pressed into pin apertures **164** except with insertion link **115** wherein shortened pivot pins **128** are utilized within pin apertures **164** (FIG. **26**). Each link **115**-**121** in this embodiment is configured with a predetermined profile suitable to performing in the insertion configuration, the expanded configuration, and transitional configurations therebetween. For example, FIG. **26** illustrates a generally S-shaped profile of the insertion link **115** from a top view.

At each joint **130**, a plurality of positional stops **165** interfering with each other are configured to limit motion at each joint when spacer **100** moves from an insertion configuration to an expanded configuration. These positional stops **165** determine the final shape of the expanded implant. In the preferred embodiment for example, the positional stops **165** help guide the implant into the open generally hexagonal profile of FIG. **10**.

The insertion link **115**, FIGS. **25-27**, comprises a pair of opposing capture tongues **158**. A control guide **144** is situated on insertion link **115** and in this embodiment is in the form of a pair of opposing grooves **145** cut parallel to axis-A through each control tongue **158**. The grooves are configured to accept control arms **350** of inserter instrument **300** when mounted to insertion link **115**. The grooves **145** comprise surfaces **146**, **143**, and **142** upon which surfaces on control arms **350** act to impart forces and direction on the insertion link **115**.

An inner wall **151** extending along axis-A defines inserter aperture **149**. Inner wall **151** may be threaded **150** for threaded attachment of insertion instrument **300**. At the proximal end of insertion link **115** is instrument stop surface **156** which abuts instrument **300** when attached to insertion link **115**.

The lateral-proximal (LP) link **121** is illustrated in FIGS. **28-30**. This link is connected by pin joint to the lateral side of inserter link **151**. LP link **168** comprises two capture grooves **157**. The deeper capture groove **157** is configured to house the elongated capture tongue **158** of insertion link **115** when elongated wall **169** of LP link abuts positional stop **165** in the insertion configuration. Situated on the inside of link **168** is instrument channel **170**. This channel accommodates portions of instrument **300** when spacer **100** is in the collapsed insertion configuration.

FIGS. **31-33** illustrate an embodiment of a medial proximal (MP) link Unlike LP link **121**, the MP link **116** comprises both a capture groove **157** and a capture tongue **158**. Some embodiments of the MP or LP links include an extension of control guide **144** in the outer surface of the link to accommodate control arms **350** of inserter instrument **300**.

Various embodiments of the lateral intermediate (LI) link **120** is illustrated in FIGS. **34** & **35**, and of the medial intermediate link (MI) **117** in FIGS. **36** & **37**. The embodiments shown illustrate an angulation between support face **140** and **141** to replicate the lumbar angle 'L' typically encountered between the endplates. This angulation between support faces may be adjusted on any of the spacer links according to the anticipated final position within the intervertebral space. For example, if a link resides obliquely within the intervertebral space, then support faces may be angled accordingly to match the intervertebral space at this orientation.

LI link **120** utilizes a capture tongue **158** on each side of the link whereas the MI link **117** utilizes one capture tongue **158** and one capture groove **157**. One or more windows **171** may be cut through the body **167** of link **117**,**120** between the inner **172** and outer **166** surface of the link.

FIGS. **38-41** illustrate various aspects of an exemplary embodiment of medial distal (MD) link **118** of spacer **100**. Like the other links, the MD link comprises a body **167** formed in the general shape of the number six. At one end, is a capture groove **157** utilized for creating a joint with adjacent MI link **117**. On one side of MD link **118** is an extensive support face **140** with teeth **108** inscribed thereon. On an opposing side is a smaller support face **141**. Located centrally within the base of the 'six', is coupling aperture **173** sized to house shaft **201** of coupling screw assembly **200**.

Situated between outer surface **166** and aperture **173** is positioner pocket **174**. Pocket **174** is configured with a support floor **176**, containing wall **177**, and stop wall **179**. Situated between inner surface **178** and aperture **173** is coupler window **175**. Cut into body **167** is instrument channel **170** to accommodate portions of instrument **300** when spacer **100** is in its insertion configuration. The body **167** of MD link **118** and LD link include a mating cutaway **182** defining mating surface **181**. MD link **118** and LD link **119** are aligned on axis-C with mating surface **181** of each link in facing opposition.

FIGS. **42-45** illustrate various aspects of an exemplary embodiment of lateral distal (LD) link **119** of spacer **100**. Again, the LD link comprises a body **167** formed in the general shape of the number six. At one end, is a capture groove **157** utilized for creating a joint with adjacent LI link **120**. One side of LD link **119** comprises an extensive support face **140** with teeth **108** inscribed thereon. On an opposing side is a smaller support face **141**. Located centrally within the base of the 'six', is coupling aperture **173** sized to house shaft **201** of coupling screw assembly **200**.

Situated between outer surface **166** and aperture **173** is positioner pocket **174**. Pocket **174** is configured with a support floor **176**, containing wall **177**, and stop wall **179**. Inscribed into support floor **176** is a C-shaped groove **180**. Situated between inner surface **178** and aperture **173** is coupler window **175**. Cut into body **167** is instrument channel **170** to accommodate portions of instrument **300** when spacer **100** is in its insertion configuration. The body **167** of MD link **118** and LD link **119** include a mating cutaway **182** defining mating surface **181**. MD link **118** and LD link **119** are aligned on axis-C with mating surface **181** of each link in facing opposition.

FIG. **23** illustrates positioner coupling assembly **204** which is comprised of; fastener pivot assembly **200** illustrated in FIGS. **12** and **13**, positioner gear assembly **205** illustrated in FIG. **22**, and coupler **206** illustrated in FIG. **16**.

Fastener pivot assembly **200** secures MD link **118** and LD link **119** together and in this embodiment is in the form of a shoulder bolt **232** releasably attached to shoulder nut **233** through threaded interengagement **231**. However, fastener pivot assembly **200** may be in other forms such as a rivet or a bolt threaded into the aperture of the opposing link Bolt **232** and nut **233** comprise opposing restraining faces **234** that secure links **118** and **119** together when nut **233** is advanced. The shoulders **230** on nut **233** and bolt **232** center links **118** and **119** along axis C. Coupler **206** comprises a rounded body **240** with pivot aperture **241** extending through body along axis D. A coupling aperture **242** extends along axis-E and is generally perpendicular to axis-D. The wall defining the coupling aperture **242** is threaded for engagement with expansion rod **304**. Stop surface **243** abuts an opposing surface on expansion rod **304** indicating the rod is fully engaged in coupling aperture **242**. Centering surface **244** encircles the outer body **240** about axis D. In an assembled configuration, end surfaces **245** position coupler **206** between the MD and LD links **118** & **119**.

Positioner gear assembly **205** is configured to hold spacer **100** in a predetermined expanded or collapsed configuration. Assembly **205** comprises an arc shaped integral spring positioner gear **209** mated with a complementing positioner gear **207** as illustrated in FIG. **22**. Illustrated in FIG. **21**, spring positioner gear **209** comprises a biasing element here in the form of an integrated undulating spring **208** or equivalent biasing member. Providing the space required to compress is compression gap **223** and limit face **224** abuts and stops further compression at support floor **176** to prevent plastic deformation of spring **208**. A foot **210** of spring **208** resides against support floor **176** of MD link **118**. In an alternate form, spring **208** may be in the form of a 'Y' as seen in FIG. **24** wherein the foot **210** is at the tip of arms of the Y, or other forms such a separate compression spring or leaf spring.

The positioner gears **209** and **207** comprise an arc shaped body **211** with radially cut teeth **212** cut into face wall **222**. A convex outer wall **213** opposes a concave inner wall **214** sized to fit around centering surface **244** of coupler **206**. At the ends of each arc are position faces **215**. As illustrated in FIG. **19-21**, positioner gear **207** comprises a seat face **216** opposite teeth **212**. Stepping below the seat face **216** is inner rim **217** comprising an outer position face **219**, an inner position face **220**, bottom face **218**, and top face **221**.

In an assembled configuration, inner rim **217** of positioner gear **207** resides in C-shaped groove **180** of LD link **119** with seat face **216** directly adjacent support floor **176**. End surface **245** of coupler **206** abuts against top face **221** to keep positioner gear **207** captured in positioner pocket **174**. Position faces **215** of positioner gears are bound by stop walls **179** therein causing positioner gear **207** or **209** to rotate about axis C only as part of rotational movement of MD and LD links **118** and **119**. Axis-E and coupling aperture **242** of coupler **206** reside within the coupler windows **175** of the MD and LD links with room to pivotably adjust as spacer **100** moves from an insertion configuration to an expanded configuration.

To create transition from insertion to expanded configuration, instrument **300** creates a tension force on coupler **206** drawing it near insertion link **115**. During this motion, MD link **118** with captured spring positioner gear **209** housed within positioner pocket **174** and LD link **119** with positioner gear **207** captured within its own positioner pocket **174**, rotate about axis-C in opposite directions. This rotational motion causes the opposing radial cut teeth **212** to move from a tip **225** to valley **227** orientation, to a tip **225** to tip **225** orientation therein imparting a translational motion of spring positioner gear **209** against spring **208**. Continued rotation will cause tip **225** to seat in a new valley **227**. This mechanical arrangement provides the surgeon a means to selectively expand or contract spacer **100** to predetermined positions once the instrument **300** imparts a sufficient tension or compression force on coupler **206**. Similarly, spacer **100** will remain in the predetermined expanded configuration once instrument **300** is removed as the patient's anatomy will be unable under normal circumstances to create forces on spacer **100** sufficient to overcome biasing force of spring **208**.

In an alternative embodiment, a nitinol leaf spring is configured about centering surface **244** of coupler with each leg of the leaf spring extending into the body of MD link **118** and LD link **119**. Said spring biases link **118** and **119** towards an expanded configuration with inserter **300** configured to work against bias force to keep spacer **100** in insertion configuration during insertion.

The spacer inserter **300** and its components are now described in greater detail. The inserter **300** comprises a control frame **301** with proximal end **331** and distal end **330** and is illustrated in FIGS. **46-57**. The frame **301** comprises an elongated body **339** with an interior wall **340** defining a central working aperture **332** sized for gliding passage of fixation tube **303** and expansion rod **304** (FIG. **2**). The outer wall **380** extends from the distal end **330** with a rectangular profile similar to spacer **100** in the insertion configuration. Extending from the distal end **330** of body **339** are one or more control arms **350** sized to be received within the opposing grooves **145** of control guide **144** of insertion link **115**. The control arms **350** comprise a plurality of torque walls **341** facing surfaces **142** and **143** on insertion link **115** and are configured to transmit a torsional force to the insertion link **115**. Surfaces **146** of the inserter link are captured between opposing walls **342** therein aligning axis-A of inserter link with axis-F of control frame **301**. Outer surfaces **343** of the control arms are sloped to minimize resistance against soft tissue during insertion and tip **345** is rounded for the same purpose. Link face **344** is secured against stop surface **156** when spacer **100** is attached to spacer inserter **300**. In this embodiment, link face **344** and stop surface **156** comprise complementary non-planar surfaces assuring proper alignment of spacer and inserter (i.e. lateral side **104** of spacer and side marked 'lateral' on inserter **300** are co-aligned).

Proximal to control arms **350** are one or more windows **338** cut into body **339** to enhance cleaning after use. At an area along body **339** positioned to reside above the skin when spacer **100** is fully inserted is a counter-torque neck **333** for attachment of a counter torque instrument. The counter-torque neck **333** is in the form of a plurality opposing torque faces **346** wherein an instrument as simple as an open ended wrench may attach and limit torsional forces transmitted to the implant through inserter **300**.

Also at proximal end **331** of control frame **301** is a bulb portion **347** of body **339**. Cut into bulb portion **347** is lock aperture **335** configured to house lock wheel **348**. Two sides of bulb **347** are substantially flattened into opposing finger faces **337** to provide access by the user's fingers to lock wheel **348**. Proximal along axis-F of body **339** from bulb portion **347** is collar neck **334** comprising threads **349** thereon configured for engagement with handle collar **302**. At the proximal end of threads **349** is indicator **351** here illustrated in the form of a groove. The groove may be painted or otherwise highlighted. Located proximal to collar neck **334** of body **339** is limiter neck **336**. The limiter neck comprises a proximal wall **352**, a centering wall **353**, a locator wall **354**, and a limiter groove **355**. In some embodiments limiter neck **336** is absent.

Handle collar **302** assembly is illustrated in FIGS. **53** and **54** and comprises an outer drive collar **367** and inner spin collar **366**. The outer drive collar **367** comprises a central aperture **369** with threaded walls **360** configured for threaded engagement over threads of collar neck **334**. At the proximal end of outer drive collar **367**, aperture **369** is enlarged to house inner spin collar **366**. Within this enlargement is collar groove **359** for seating expansion ring **368**. Ring **368** also encircles inner spin collar **366** within ring groove **361** therein securing inner spin collar **366** within outer drive collar **367** but providing for free rotation of one collar about the other.

Outer collar **367** also comprises a distal stop surface **355** which when abutted against bulb portion **347** is configured as the starting point for collar **367** prior to transitioning spacer **100** from insertion configuration to expanded configuration. Distally on outer collar **367** is drive **370** configured for moving collar by attachment of expansion handle **306**. Drive **370** in this embodiment is in the form of several flat drive surfaces **357** formed in a hexagon encircling central aperture **369**. Cut into each drive surface **357** is lock aperture **358**. Proximal to inner threaded walls **360** is inner surface **356** sized to house outer surface **364** of inner spin collar **366**. Inner spin collar **366** further comprises a spin aperture **362** defining an inner surface **365** enlarged to ride slightly above collar neck **334** threads. At proximal end of spin collar **366** is limiter surface **363**.

Fixation tube **303** is further illustrated in FIG. **55**. The tube **303** comprises a linear elongated body with inner cannula **371** extending the length of the tube and cannula sized to house fixation rod **304** to slide therein. The outer surface **373** of tube **303** at the distal end is configured with threads **372** for threaded engagement with threads **150** of insertion link **115**. Nearing the proximal end, tube **303** is perforated with pin apertures. Fixators **374** in the form of fixation pins extend through lockwheel **348** and are housed within said pin apertures to fix lockwheel **348** in a predetermined location on tube **303** wherein when tube **303** is housed within control frame **301**, lockwheel **348** freely spins within lock aperture **335**.

FIGS. **2** and **4** further illustrates expansion rod **304**. Protruding from the distal end of rod **304** is a threaded boss **375** configured for threaded engagement within coupling aperture **242**. Stop surface **376** abuts stop surface **243** of coupler **206** when rod **304** is fully engaged within aperture **242**. At step **320**, rod **304** decreases in diameter.

The expansion limiter **305** prevents over expansion of spacer **100** when transitioning to the expanded configuration by limiting travel of expansion rod **304**. The limiter **305** comprises a housing **315** with non-circular inner aperture **377** complementing profile of limiter neck **336** for sliding translational movement but not rotary. Cut into side of housing **315** is clip slot **378** configured for sliding entry of clip **318** therein securing housing **315** to expansion rod **304** proximal to step **320**. Lock button **316** is housed in a button aperture **394** on side of housing (not viewable). Lock button **316** comprises elongated slot **317** wherein a rib (not viewable) within slot **317** releasably engages limiter groove **355** of control frame **301**. Biasing member **379** keeps rib engaged in groove **355** until lock button **316** is depressed by user providing for release of limiter **305** from limiter neck **336**.

Expansion handle **306** comprises a T-shaped body **321** as illustrated in FIGS. **56-57** and FIG. **4**. Cut into the front side of body **306** is head recess **381** sized to house enlarged head **310** of expansion rod **304**. At the base of the head recess **381** is head shelf **384** to capture head **310** in head recess **381**. Cut into head shelf **384** is a narrowed neck slot **382** to provide passage of the elongated rod body of expansion rod **304**. Distal to head shelf **384** is limiter recess **385** configured to house expansion limiter **305**. Collar recess **386** is situated distal to limiter recess **385**, and is configured to fit over handle collar assembly **302**. The collar recess **386** is bounded by two opposing collar drive surfaces **387** and a collar shelf **383**. Cut through collar shelf **383** is control aperture **388** sized to pass collar neck **334** of control frame **301** while simultaneously capturing outer drive collar **367**. This open configuration of head recess **381**, neck slot **386**, limiter recess **385**, collar recess **386**, and control aperture **388** provide the means for rapid sideways removal of expansion handle **306** from the inserter **300**. With handle **306** connected to inserter **300**, torsional force applied by user to handle is transmitted through collar drive surfaces **387** to drive surface **357** of outer drive collar **367** therein causing handle collar assembly **302** to advance proximal or distally along with expansion rod **304** further causing spacer to transition between insertion and expanded configuration.

One or more handle locks **307** releasably secure expansion handle **306** to handle collar **302**. Each lock **307** comprises a lock lever **389** and bias member **312** in the form of a coiled spring. The lock lever **389** in this embodiment is in the shape of a teeter-totter comprising a pivot member **313** in the form of a pin, and a plunger **314**. Lock lever **389** resides in lever recess **311** within body **321** of handle **306**. The lever **389** is pinned into recess **311** by pivot member **313** extending between pivot apertures **309** and through body of lever **389**. Spring force produced by bias member **312** causes plunger **314** to occupy plunger hole **310** and extend into collar recess **386** while simultaneously filling lock aperture **358** of outer drive collar. The handle is removed by the user by placing finger force on lever release surfaces **308** therein causing plungers **314** to retract and sliding handle **306** away.

On the rear side of expansion handle **306** is viewing window **390** cut between the outer wall of body **321** into limiter recess **385**. Although expansion limiter **305** is viewable from the opposing side of the handle **306**, window **390** provides a more intuitive method for viewing progress of spacer **100** transition from one configuration to another by noting position of limiter within window **390**. For convenience, head drive pocket **391** is integral to expansion handle **306**. This pocket **391** is configured with drive faces **392** complementing enlarged head **310** of expansion rod **304** wherein when handle **306** is removed from collar **302**, it can be used to apply greater torque to head **310** when necessary.

There are several different approaches to filling spacer **100** with graft material once inserted into the pre-determined location within the intervertebral space and transitioned to the expanded configuration. The insertion instrument may be removed and a graft filling instrument may be attached to insertion link **115**. This instrument may be the form of an upright funnel with an elongated plunger at the proximal end, wherein the plunger pushes graft material down an elongated tube extending to the insertion link and into graft aperture **122**. In an exemplary embodiment, a graft inserter assembly **500** is illustrated in FIG. **58**. The graft inserter is configured to cooperate with the spacer & insertion assembly **101** to introduce bone graft into graft aperture **122** of spacer **100**. The inserter **500** comprises a graft cartridge portion **501**, a cartridge retainer portion **502**, and a graft delivery guide portion **503**.

The graft cartridge portion **501** in this embodiment is further illustrated in FIGS. **66-68**. It comprises a chute housing **504**, a cartridge door **505**, and cartridge handle **506**. The housing **504** is formed of a flat rectangular body **537** with a plurality of chutes **507**, in this case partially opened, traveling from a proximal end top surface **516** to a distal end bottom surface **518** of chute housing **504**. The chutes **507** have a chute wall **508** defining a cylindrical aperture configured for storage of graft and passage of a plunger to push the graft material in the chutes **507** from a proximal end to a distal end of the chute. The plunger for example, may be in the form of the expansion rod **304** described earlier but with a blunt tip and length sufficient to push bone graft from the chutes **507** into graft aperture **122** of spacer **100**. The chutes **507** may be open on one side along their length and separated by chute divider surface **509**.

A handle **506** is fixed to chute housing **504**, here by means of fixing pins **510** holding posts **511** in bores **512** located on the opposing side of chute housing **504**. Handle **506** provides eased insertion and removal of chute housing **504** from cartridge retainer portion **502**. A lock recess **513** cooperates with a releasable lock **514**, here in the form of a spring pin on the cartridge retainer **502** to secure chute housing **504** within retainer **502**. A pair of opposed channels **515**, one of them wedged, are situated within side wall **517**. The channels **515** cooperate with bosses (not shown) within the cartridge retainer **502** to assure the chutes are properly centered within the retainer for the transfer of graft material therethrough.

A cartridge door **505**, here in the shape of a flat square, comprises a hinge channel **519** for cooperation with hinge channel **520** and hinge pins **521**. When removed from cartridge retainer portion **502**, the graft cartridge **501** may be placed on a table laying on handle **506** with the graft door **505** opened therein exposing the open chutes **507**. Graft is then spread across the chute divider surfaces **509** and massaged into the open chutes until they are full. Excess graft is wiped from surface **509** and the graft door **505** is closed. The graft cartridge **501** can then be inserted into the retainer portion **502**.

FIG. **60** illustrates an exploded view of a cartridge retainer **502** illustrated in FIG. **59**. The retainer **502** comprises a cartridge retainer housing **522** with a rack gear **523** fixed to the housing with locator pins **531** and fasteners **530**. Releasable lock **514** is mounted to housing **522** within lock port **535** and comprises a lock plunger **532**, plunger biasing member **533** here in the form of a spring, and a release knob **534**. The spring biases the plunger towards interfering with lock recess **513** of chute housing **504** to secure it within retainer housing **522** until surgeon desires to remove it.

The cartridge retainer housing **522** is further illustrated in FIG. **61-63**. The housing comprises a body **540** with top face **541**, front face **542**, opposed side faces **543**, rear face **544**, and bottom face **555**. Linearly cut into the rear face **544** is rear guide recess **545** bounded by a lower guide wall **546** and an upper guide wall **547**. Similarly, cut into the front face **542** is front guide recess **548** defining an upper foot **550** and lower foot **549**. The front guide recess **548** is bounded by a lower guide wall **546** and an upper guide wall **547**. A cartridge aperture **550**, bounded by boundary walls **552**, extends from the top face **541** through the body **540** and bottom face **555** and is configured in size and profile to house graft cartridge **501**. A handle recess **549** is cut through the rear face **544** and top face **541**. It is here cartridge handle **506** resides and stop surface **551** abuts handle **506** when cartridge **501** is fully seated within the cartridge aperture **550**. On side face **543** is auxiliary port **553** with plug **554**.

Cut into front face **542** and bottom face **555** are chute door recesses **556** to provide housing of chute doors **527**. Base wall **560** and containment walls **557** guide the chute doors **527** down a linear path and hold the doors within the recesses **556**. At the end of the recesses **556** is pin aperture **558** to hold one end of door pin **524**. Each chute door recess **556** is separated by a chute wall **559**. Also cut into front face **542** and bottom face **555** is chute plate recess **561** for housing of chute plate **528**. Located on base wall **564** of recess **561** is locator pin aperture **563** and threaded hole **562**. Similarly, located on upper guide wall **547** are pin apertures **563** and threaded hole **562** for placement of rack gear **523** and securement with fasteners **529**.

As illustrated in FIG. **65**C, chute doors **527** reside within the chute door recesses **556**. The chute door **527** in this embodiment comprises an L-shaped body **565** with enlarged head **566** (FIGS. **65**A & **65**B). The chute door **527** is configured to slide along door pins **524** and resides between base wall **560**, chute wall **559**, and containment wall **557**. The door **527** comprises a pin aperture **567** for passage of door pin **524** and a counter bore **568** to house end of biasing member **525**. Chute door **527** further comprises a pair of opposing side walls **571**, and bottom wall **570**. Graft face **569** of chute door **527** seals chutes **507** during operation until the chute door is retracted for graft removal. Retraction of individual chute door is controlled by retraction face **573** which is sloped and rides in high door groove **611** of graft delivery guide **503** (FIG. **70**) and boss face **568** of boss **572** rides in low door groove **611**. Portions of this mechanism are illustrated in FIG. **64** wherein a portion of the chute doors **527** are retracted therein permitting release of graft (may be assisted by a chute plunger), and others are fully covering of chutes **507**.

FIG. **69** illustrates an exploded view of an exemplary embodiment of a graft delivery guide portion **503** of graft inserter **500**. The guide portion **503** comprises a coupler **600** with a U-shaped body configured to hold cartridge retainer **502** on a base wall **602** and two opposing upright walls **601**. Projecting inward from each upright wall **601** is capture wall **603**. One capture wall **603** is configured to be received within the rear guide recess **545**, and the other within the front guide recess **548** wherein cartridge retainer **502** is captured within coupler **600**.

At the bottom of the U-shaped body is inserter tube **604** with cannulated fastener **605** configured to fix tube **604** to coupler **600** by threads on fastener **605** (not shown) threading into coupler aperture **606**. Fixing pin **607** prevents release of inserter tube **604** from coupler **600**. Pinion gear **608** resides in pinion aperture **609** and is secured in place by pins **622** about pinion shaft groove **612** when pins are pressed into pin holes **621**. Pinion gear **608** comprises a locking aperture **613** extending therethrough for housing locking pin **615**. Pinned to the end of the shaft of pinion gear **608** is handle **616** using pins **619**.

The handle **616** comprises a sliding lock button **618** pinned to handle **616** utilizing pin **617**. Sliding lock button **618** comprises a sloped activation surface **620** configured to engage locking pin **615** wherein when button **618** is slid in one direction, activation surface **620** will cause locking pin **615** to travel towards cartridge retainer **502** and held within one selector hole **536** of cartridge retainer housing **522** therein locking it in position. When button **618** is slid in the opposite direction, a gap is created between activation surface **620** and locking pin **615** wherein spring **614** will cause locking pin **615** to be removed from selector hole **536**. In this 'unlocked' position, the cartridge retainer housing **522** is free to translate parallel to upright walls **601**. Indicator **613** aligns with indicia **574** to indicate the specific chute **507** aligned with graft port **623** of cannulated fastener **605**.

As an alternative the graft inserter assembly **500**, a graft funnel **700** is illustrated in FIGS. **71-76**. FIG. **71** illustrates an exploded view of graft funnel **700**. It comprises funnel **701**, collector tube **702**, plunger tube **704**, sealing spring **705**, ball **706**, detent spring **707**, and rotation knob **703**. Graft funnel **700** comprises a broad open mouth **708** with inclined funnel walls **709** leading to an elongated funnel outlet **710**. Outlet fitting **711** is configured for fit and secured in funnel inlet **712** of collector tube **702**. The collector tube **702** comprises a tubular elongated body **713** with central aperture **714** along entire length of body **713** defining inner surface **718**. Proximal to threads **716** is spring wall **719** serving as a fixation surface for spring **705**. On outer surface of the collector tube at the distal end is grip **715** configured with ribs, knurling or other feature to ease user insertion of funnel **700** on the inserter. At the proximal end are opposing ears **721** with a blind hole **717** drilled from one side of the ear to house a ball detent mechanism **706**,**707** cooperating with plunger tube **704**. Proximal face **720** faces rotation knob **703**.

Plunger tube **704** comprises an elongated body **727** with central aperture **728** defining inner collector wall **730**. Aperture **728** is sized to pass plunger type expansion rod for pushing graft toward spacer **100**. At the distal end is enlarged head **725** terminating with inserter face **726**. Graft inlet window **729** provides for passage of graft material from funnel **701** into central aperture **728**. Proximal to graft inlet window **729** is an elongated detent groove **724** for cupping ball **706** that provides a small amount of translation of plunger tube **704** within collector tube **702**. An opposing detent groove **724** is mirrored on opposing side of plunger tube **704**. This ball detent system with elongated not only holds plunger tube **704** within collector tube **702**, it also provides the users a means to quickly align the graft inlet window **729** with funnel outlet **710** to provide for graft placed into funnel **701** to flow into and fill central aperture **728** of plunger tube **704**. Knob **703** comprises central aperture **722** having aperture walls configured to act on torsion faces **723** of plunger tube **704**. A 180 degree turn of knob **703** by the user will in turn rotate plunger tube **704** to opposing ball detent groove **724** therein sealing off the central aperture **728** of plunger tube **704**. Knob **703** further comprises a widened aperture **731** at its proximal end through which expansion rod style plunger, as described earlier, is utilized to push the graft housed in the plunger tube **704**, through the fixation tube **303** and into graft aperture **122**.

FIGS. **77-79** illustrate spacer template **800**. Individual template instruments **800** correspond to specific spacer **100** sizes and are used as a quick method of validating the fit of a spacer **100** prior to implantation in the intervertebral space. Template **800** comprises a template spacer **801** further comprised of a series of pinned template links **802** generally replicating links **116-121** of spacer **100** with a few differences. One difference is teeth **108** on spacer **100** are absent and replaced with a smooth surface **804** to provide eased insertion and removal of template **800** in and out of the intervertebral space. Windows **171** extending through inner surface **172** of select links may be removed. In addition, the functional components of coupler **206** are now integrated into expansion rod **806** and positioner gears **207** and **209** are removed. The functionally equivalent MD and LD links **118**, **110** in the template spacer have been modified accordingly to house coupler **807** of expansion rod **806**.

Expansion rod **806** comprises an elongated body **829**. The distal end of the rod **806** flattens into coupler **807** generally comprising a round disc with central aperture sized to house a fastener similar to fastener pivot assembly **200** used to secure links and coupler together. Located on the proximal end of expansion rod **806** are torsion features, here in the form of a male flat **808**, to inter-attach rod **806** within corresponding female flat **825** within expansion drum **810**. Pin **812** secures drum **810** to rod **806** through pinhole **809**. Located on the outerbody of expansion drum **810**, preferably at the proximal end is indicator **811** that is viewable through window **815** of handle **814** to monitor expansion progress of template spacer **801**. The outerbody of expansion drum **810** comprises threads complementing threads **826** within drum aperture **817**. At the distal end of drum aperture **817** is retainer groove **816** sized to house a portion of spring retainer ring **813**.

Control tube **803** comprises an elongated body **821** with central rod aperture **824** extending therethrough and sized to house sliding expansion rod **806** therein. At the proximal end of control tube **803** is retainer groove **819** formed within control tube head **818**. The retainer groove **819** is also configured to house a portion of spring retainer ring **813** wherein the ring holds handle **814** to control tube head **818** yet provides for rotational movement therebetween. Just below head **818** are torsional flats **820** for attachment of a counter torque device such as an open end wrench or similar device. At the distal end of control tube **803** is link control head **828**. The head comprises one or more bosses **823** each having an integrated pin aperture **827**. The control head **828** is held with pins **822** to the corresponding template spacer links **802**. The corresponding insertion link **115** is integrated into control tube **803** of spacer template **800** since the template links are not required to be released from the template instrument. However, in alternative embodiments, it is contemplated that control tube **803** may be configured to be releasable from various spacer templates **800**. The outer surface of the control tube may include indicia **830** to indicate instrument orientation (i.e. medial or lateral). By rotation of handle **814**, spacer template **800** is capable of transforming template spacer **801** between insertion and expanded configurations.

In an exemplary embodiment, the spacer **100** and method are configured for a transforaminal surgical approach. The patient is placed on a radiolucent surgical table in the prone position. A retractor is positioned over the pre-determined operative level. Anatomic landmarks are identified followed by initial incisions localized at the disc space using fluoroscopy in the anterior/posterior (A/P) and lateral views. A radiograph is taken and additional radiographs are taken at any time at the surgeon's discretion.

The patient's pedicles are targeted above and below the affected level and the location of each is marked. A skin incision is made between the pedicle markings with sizing appropriate for the retractor used. Using finger dissection, a cobb, or curette, tissue is released from the facet joint at the affected level. Fascia or tissue at the pedicles preventing placement of the retractor is removed. The retractor is inserted over the facet joint and positioned and secured to be parallel to the disc space for the proper medial exposure trajectory.

The surgeon then performs a conventional facetectomy and decompression followed by annulotomy and discectomy. Using any combination of pituitary rongeurs, disc cutters, endplate scrapers, curettes, and rasps, the surgeon removes as much disc material from the disc space as possible. A variety of angled instruments are then used to prepare the contralateral/posterior and ipsilateral/anterior regions of the disc. The endplates are prepared to remove cartilage and expose bleeding subchondral bone.

An appropriately sized spacer template **800**, with template spacer **801** in the collapsed configuration is selected and inserted down the surgical path at an oblique angle with the "MEDIAL" and "LATERAL" markings **830** on the instrument in the correct orientation relative to the patient's spine. The template is inserted until the distal tip **831** of spacer **801** abuts the annulus at the anterior/contralateral region of the disc space (FIG. **80**). Using lateral fluoroscopy, the distal tip **831** is confirmed to be abutting the anterior annulus. Using anterior-posterior (A/P) fluoroscopy, the distal tip is checked to assure it abuts the projected medial border of the contralateral pedicle. If necessary, a surgical mallet is used to impact the proximal end of handle **814** until it reaches the desired location.

Under A/P and lateral fluoroscopy, the handle **814** of template **800** is advanced by clockwise rotation to expand the template (FIG. **81**). Full expansion can be confirmed via fluoroscopy as the notches on the expanded template will be coincident in the direct A/P and direct lateral views as indicated in FIG. **82**. Full expansion can be confirmed via visual indicator on the footprint template handle as illustrated in FIG. **83**.

The spacer template **800** is transitioned prior to removal by rotating the template handle counter-clockwise until it returns to a collapsed insertion configuration. The surgeon will choose an alternate sized spacer template if necessary until the proper spacer template size has been determined using tactile feel and fluoroscopy. Additional disc tissue may be removed as needed to facilitate full expansion.

An appropriately sized paddle sizer is then chosen as illustrated in FIG. **84**. A T-handle is attached to the end of the sizer and inserted into the disc space using an oblique trajectory. Appropriate "MEDIAL" and "LATERAL" instrument markings are followed if the sizer is rotated to height relative to the patient. The sizing iterations are continued until the proper height and lordosis have been determined using tactile feel and lateral fluoroscopy.

An appropriately sized spacer **100** is then chosen and attached to the spacer inserter **300** by aligning the control arms **350** with control guide **144** on insertion link **115** and advancing together. Lockwheel **348** is rotated (clockwise) until fixation tube **303** threads **372** advance into aperture **149** and instrument stop surface **156** on insertion link **115** is tight against link face **344** on control frame **301** as illustrated in FIG. **85**.

Handle collar assembly **302** is advanced on collar neck **334** of control frame **301** until distal stop face **355** abuts bulb portion **347** of control frame **301** as illustrated in FIG. **86**. An optional expansion limiter **305** may be attached to limiter neck **336**. An appropriately sized expansion rod **304** corresponding to the spacer **100** size is selected. Using enlarged head **310**, and leading with threaded boss **375**, the expansion rod **375** is advanced through working aperture **332** of control frame **301** and threaded (clockwise) into coupler aperture **242** of coupler **206** until stop surface **243** abuts stop surface **376** on expansion rod **304** as illustrated in FIG. **87**. Expansion handle **306** is then mounted over outer drive collar **367** while spacer **100** remains in the insertion configuration as illustrated in FIG. **88**.

Spacer **100** is then inserted down the surgical path into the disc space using an oblique trajectory while ensuring that the "MEDIAL" and "LATERAL" indicia **393** are in the correct orientation relative to the patient. Under fluoroscopy, the implant is expanded through rotation of the expansion handle as illustrated in FIG. **89**, while a distal directed force is maintained during expansion and the anterior aspect of the implant in monitored via fluoroscopy to assure it remains in the desired location. Tactile resistance may be felt when the implant is in its fully-expanded state. Full expansion can be confirmed via fluoroscopy as well as by visual indicator **351** on the implant inserter as seen in FIG. **90**. Radiographs may be taken to confirm correct placement of spacer **100** in the intervertebral space. If desired, handle **306** may be derotated to return to the insertion configuration for spacer **100** removal or readjustment. When fully collapsed, the rotating collar on the inserter will be fully seated distally. Once proper placement is achieved, expansion handle **306** is removed from spacer inserter **300** by releasing handle lock **307** (if so equipped) and sliding handle **306** off as seen in FIG. **91**.

The expansion rod **304** is released from coupler **206** through derotation of enlarged head **310** as illustrated in FIG. **92**. The handle collar assembly **302** is rotated until distal stop face **355** abuts bulb portion **347** of control frame **301** as illustrated in FIG. **93**. Graft funnel **700** as illustrated in FIG. **94**, or graft inserter assembly **500** may now be attached to collar neck **334** (limiter neck **336** may be absent in some embodiments).

The graft funnel **700** is attached by advancing threaded **716** aperture of collector tube **702** over collar neck **334** until snug. The funnel **701** is filled with autograft guided into the central aperture **728** of plunger tube **704** until full. Using knob **703**, the plunger tube **704** is rotated until ball detent engages at 180 degrees. An expansion rod style plunger is advanced down widened aperture **731** pushing graft into graft aperture **122** of spacer **100**. This action is repeated until graft aperture is filled to the desired level. The funnel **700** is then removed from the implant inserter followed by removal of the implant inserter by rerotation of lockwheel **348** therein releasing spacer inserter **300** from spacer **100** as illustrated in FIG. **95**.

The retractor and all instruments are then removed from the patient. The surgeon my choose to take an A/P fluoroscopy image of the operative site with the C-Arm at 0 degrees and a lateral image with the C-Arm at 90 degrees. The applicable steps from above are utilized if additional implants are desired at an additional operative level as chosen by the surgeon.

In an alternative method to using graft funnel **700**, graft delivery guide **503** is attached by advancing inserter tube **604** over collar neck **334** and tightening until snug. The cartridge retainer is set on a flat sterile surface against cartridge handle **506** with door **505** facing up. Door **505** is opened and bone graft is spread across chutes **507**. Door **505** is closed once chutes **507** are filled with desired amount of bone graft. Lock **514** is withdrawn and cartridge retainer **501** is inserted into cartridge aperture **550** of the cartridge retainer housing **502** and secured by releasing lock **514**.

The cartridge retainer housing **502** with cartridge retainer is then loaded into the right side of graft delivery guide wherein rear guide recess **545** and front guide recess **548** are captured between capture walls **603**. With sliding lock button **618** unlocked, handle **616** is rotated counter clockwise causing pinion gear **608** to advance rack gear and cartridge retainer **502** across coupler **600** until a selected chute aligns with indicator **613**. Sliding lock button **618** may be engaged to secure cartridge retainer in place. The chute door **527** aligned with indicator **613** at center of coupler **600** is opened by walls of curved low door groove **610** and high door groove **611** acting on retraction face **573** and boss face **568** against biasing member **525**.

A fixation rod style plunger is used to push the bone graft for said open chute through graft port **623** and fixation tube **303** into graft aperture **122**. The cartridge retainer **502** is advanced by the pinion gear **608** to the next chute and the plunger process is repeated until a desired amount of graft is pushed into graft aperture **122**. The graft inserter assembly and spacer inserter may then be removed.

While the present invention has been shown and described in terms of preferred embodiments thereof, it should be understood that this invention is not limited to any particular embodiment and that changes and modifications may be made without departing from the true spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. An intervertebral spacer, comprising:

a first side having a proximal end and a distal end and comprising a first plurality of links joined by a first plurality of joints;

a second side having a proximal end and a distal end and comprising a second plurality of links joined by a second plurality of joints;

a proximal end including an insertion link having an aperture dimensioned to receive an insertion tool, said insertion link joined to proximal ends of the first side and the second side;

a distal end including a coupling assembly for receiving a portion of the insertion tool;

a first support face configured to contact a first vertebral body endplate; and

a second support face opposite said first support face configured to contact a second vertebral body endplate,

wherein said intervertebral spacer has an insertion configuration in which the spacer is elongated and the first side and the second side are linear and an axis of insertion is parallel to a longitudinal axis of the intervertebral spacer, and a fully expanded configuration in which the first side and the second side are displaced to define a graft aperture therebetween, and the intervertebral spacer has a hexagonal perimeter that is asymmetrical about the axis of insertion;

a positioner gear assembly housed in the distal end of the spacer, and configured to maintain the intervertebral spacer in an expanded configuration.

2. The intervertebral spacer of claim **1**, wherein the intervertebral spacer is bisected by a first axis parallel to a sagittal plane when the spacer is in the fully expanded configuration within an intervertebral disc space.

3. The intervertebral spacer of claim **2**, wherein the perimeter of the intervertebral spacer is symmetrical about the first axis.

4. The intervertebral spacer of claim **1**, wherein at least one of the plurality of links of the first side includes a window.

5. The intervertebral spacer of claim **4**, wherein at least one of the plurality of links of the second side includes at window.

6. The intervertebral spacer of claim **1**, wherein the first side has a first height at the distal end and a second height at the proximal end and wherein the first height is greater than the second height.

7. The intervertebral spacer of claim **6**, wherein the second side has a first height at the distal end and a second height at the proximal end and wherein the first height is greater than the second height.

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